UNIVERSITEIT GENT

FACULTEIT PSYCHOLOGIE EN
PEDAGOGISCHE WETENSCHAPPEN

Directing attention away from pain in children and adolescents: An experimental approach

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Proefschrift ingediend tot het behalen van de academische graad van Doctor in de Psychologie

2011

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ACKNOWLEDGEMENTS

In 2003 behaalde ik mijn master in de klinische psychologie. Het duurde echter een tijdje voor ik wist wat ik echt wou. In augustus 2006 vielen alle puzzelstukjes op de juiste plaats en begon ik mijn reis als PHD student. Op het einde zou ik graag de gelegenheid nemen om enkele mensen te bedanken, die me tijdens deze reis vergezelden…

Paulette, als voormalig vakgroepvoorzitster hebt je me nooit losgelaten en zorgde je ervoor dat ik de weg naar de UGent altijd terugvond.

Geert, als huidige vakgroepvoorzitter en tevens mijn promotor zou ik je heel erg willen bedanken voor alle kansen en uitdagingen die je me geboden hebt bij het uitwerken van dit doctoraat. Dankzij jou is mijn onderzoeksinteresse doorheen de jaren steeds gegroeid en blijf ik mijn grenzen steeds verleggen.

Stefaan en **Liesbet**, als lid van mijn begeleidingscommissie hebben jullie me steeds met goede raad en feedback bijgestaan. Maar jullie deden ook zo veel meer. Op de momenten waarop dit het meeste nodig was, boden jullie me een vangnet. Dit zal ik nooit vergeten.

Johan, bedankt voor je oprechte interesse in mijn onderzoek en de vele interessante gesprekken tijdens meetings en congressen. Ik heb jouw input tijdens de begeleidingscommissies altijd erg gewaardeerd.

Rudi, bijna had ik mijn doctoraat onder jouw supervisie uitgevoerd. Achteraf bekeken ben ik blij dat ik in het pijnonderzoek terecht gekomen ben, omdat dit beter aansluit bij mijn persoonlijke interesses. Als lid van de begeleidingscommissie kon je me van op een afstand toch blijven volgen en daar ben ik blij om.

Chris, thank you for pushing me to the limit. I value the time we spend writing together. I didn't always liked what you said, but I always appreciated the result. I learned a lot from you over the past years!

Tiina, **Stephen**, **Bruce**, I was honored writing with you.

Dimitri, je bent tijdens de afgelopen jaren een enorme steun voor mij geweest. Bedankt voor de vele discussies, de praktische en emotionele steun, de computerhulp, en zo veel meer. Jij gaf me de zekerheid op momenten waarop ik die zelf niet had.

Emelien, bedankt voor de vele geschifte, dromerige, gefrustreerde maar ook serieuze gesprekken, die me door de moeilijke momenten sleurden. Ook heel erg bedankt voor je inzet, steun en hulp bij het onderwijs. Het was fijn om samen met jou, **Annabelle** en **Herlinde** de schouders onder de vele onderwijsprojecten van de afgelopen jaren te zetten.

Tine en **Line**, het was heel fijn om samen onderzoek uit te denken en uit te voeren. Bedankt ook aan de overige leden van het **pijnteam**, voor de inspirerende vergaderingen, de fijne congressen en het nalezen van de teksten.

Lore, **Eva**, **Sarah**, **Ruben**, **Lieselotte**, **Barbara**, **Frederik**, **Elke en Christof**, als thesisstudent hebben jullie meegeholpen met het verzamelen en inputten van de data. Bedankt daarvoor!

Pascal en **Armand**, bedankt voor de technische ondersteuning van de verschillende onderzoeken.

De onderzoeksschool **P&H** wil ik bedanken voor de opleidingsmogelijkheden tijdens mijn doctoraat. Mede daardoor kon ik mijn onderzoek vanuit een breder kader benaderen.

Verder wil ik ook alle **scholen**, **leerkrachten**, **directies**, **kinderen**, **ouders** en **studenten** bedanken die deelnamen aan de verschillende onderzoeken.

Bedankt ook aan mijn **collega's** van de PP05 en aan mijn **vrienden** en **familie** voor hun practische en emotionele steun de afgelopen jaren en voor het nalezen van de teksten! In het bijzonder wil ik hierbij mijn **ouders** bedanken omdat ze me steeds alle mogelijkheden geboden hebben om mijn studies te voltooien.

Een speciale dankjewel gaat tenslotte naar **Alex**. Jouw steun en hulp zaten in de kleine dingen, die eigenlijk zoveel betekenden. Alles wat je voor mij gedaan hebt, neem ik zeker niet als vanzelfsprekend, maar je doet het zo vanzelfsprekend lijken. Bedankt, schat...

Katrien

Maart 2011

GENERAL INTRODUCTION

PREAMBLE

Pain is a common experience, which affects the quality of life of many, and poses a strong financial burden on the health care system (Breivik, Collett, Ventafridda, Cohen, & Gallacher, 2006; Perquin et al., 2000). Research on pain reducing strategies is therefore an important goal in today's society. Distraction, or directing attention away from pain, is a strategy that is often intuitively used to cope with pain (Leventhal, 1992), and is part of many pain treatment programs (Morley, Shapiro, & Biggs, 2004; Powers, 1999). Empirical evidence concerning the effectiveness of distraction, however, is equivocal (Eccleston, 1995b; Seminowicz & Davis, 2007a; Van Damme, Legrain, Vogt, & Crombez, 2010). Mixed research findings may be the result of methodological problems in research designs and methodological differences between studies (Eccelston, 1995b; Piira, Hayes, & Goodenough, 2002). Mixed findings may also point to the role of influencing factors of distraction effectiveness (Eccleston & Crombez, 1999; Kleiber & Harper, 1999). Nevertheless, research investigating the impact of influencing factors of distraction effectiveness is scarce, especially in children and adolescents (Kleiber & Harper, 1999; Piira et al., 2002). This dissertation aims to gain new insights in distraction research by investigating the role of beliefs, pain catastrophizing and executive functioning as potentially influencing factors of distraction effectiveness in children and adolescents. For this purpose, a research design was developed which takes into account most methodological problems in previous distraction research. Results of this research can be used to increase our knowledge of the underlying processes of distraction effectiveness in order to improve its use.

The general introduction starts with a description of the main concepts, pain and distraction. Attention will be paid to the definition, prevalence and impact of pain. Distraction will be defined, and its putative working mechanism described. The introduction continues with an overview of the distraction literature, including the common methodological problems in the field. Furthermore the relationship with influencing factors will be discussed. Finally, the aims and the outline of this dissertation are presented.

PAIN

The International Association of Pain (IASP) defines pain as "an unpleasant sensory and emotional experience, that is associated with actual or potential tissue damage or is described in terms of such damage" (IASP, 1994). This definition underlines three important aspects of the pain experience. First, pain is not entirely characterized by bodily sensations, but is often accompanied by emotions, such as anger, sadness and anxiety. Pain can therefore be described in terms of its sensory and affective dimensions, which are to some point interrelated, but can also be differentiated (Fernandez & Turk, 1992). Second, tissue damage has no direct relationship with pain or disability. For instance, pain can occur in the absence of tissue damage (e.g., phantom pain, tension headache), but tissue damage can also occur in the absence of pain (e.g., injury during sport activities, myocard infarct) (Eccleston, 2001; Fernandez & Turk, 1992; Fordyce, 1988; King, 2000). Third, the pain experience is subjective, and not exclusively determined by objective biological factors, such as the severity or the location of the injury. Such biomedical idea that has existed for a long time since Decartes' dualism of mind and body, was profoundly challenged by the "gate control theory" of Melzack and Wall (1965). According to this theory, a metaphorical "gate", which is situated in the spinal cord, modulates nociceptive impulses before they reach the cerebral cortex. The "gate control theory" situated the experience of pain within a broader biopsycholsocial perspective, by stating that not only physiological, but also psychological factors (e.g., attention, depression, anxiety) can open or close the gate, and can therefore influence the pain experience. As a result, people can actively impact their pain experience, for instance by directing their attention away from pain.

Different taxonomies can be used to classify pain. Due to the complex nature of pain, however, each classification system has it shortcomings. One possible classification method is based on the origin of pain (Koleva, Krulichova, Bertolini, Caimi, & Garattini, 2005; Russo & Brose, 1998; Serpell, Makin, & Harvey, 1998). Nociceptive pain is caused by tissue damage. The pain results from the activation of nociceptors in the skin, bones, muscles, fascia and joints (i.e., somatic nociceptive pain), or from internal organ stimulation (i.e., visceral nociceptive pain). Somatic nociceptive pain can be accurately localized, whereas visceral nociceptive pain is more diffuse and hard to localize. Neuropathic pain is caused by damage to the nervous system, which creates a burning electrical sensation. However, in many cases the origin of the pain is unknown, making a classification based on the origin of the pain hard to maintain (Merskey, 2007). Another possible classification is based on the duration of the pain (King, 2000; Turk & Melzack, 2001). Acute pain is known to last for less than 3 months (e.g., Chung & Wong, 2007; Renton, 2008; Saastamoinen, Leino-Arjas, Laaksonen, & Lahelma, 2005). The pain has a clear function, and often signals injury, disease or abnormal muscles functioning. When the damage is restored, the pain disappears. When the pain persists long after spontaneous recovery should have taken place, pain is labelled chronic (Loeser & Melzack, 1999; Renton, 2008; Russo & Brose, 1998). The pain is no longer functional, and psychosocial factors are believed to play a role in maintaining the pain problem (e.g., catastrophizing, fear of movement). The duration interval that is used to define chronic pain greatly differs across studies. Most studies operationalize chronic pain as lasting longer than 3 months (e.g., Andersson, Eijlertsson, Leden, & Rosenberg, 1993; Català et al ., 2002; Chung & Wong, 2007; Saastamoinen et al., 2005; Toth, Lander, & Wiebe, 2009; Watkins, Wollan, Melton, & Yawn, 2008). Others use a cut-off of point of 6 months (e.g., Breivik et al., 2006; Gureje, Von Korff, Simon, & Gater, 1998). As a result, large variations in chronic pain prevalence are reported (Watkins et al., 2008).

Pain is a very common experience in adults (Breivik et al., 2006; Chung & Wong, 2007; Saastamoinen et al., 2005), and is often the reason for seeking medical help (Hasselström, Liu-Palmgren, & Rasjö-Wraak, 2002; Koleva et al., 2005). The prevalence of acute pain greatly differs across studies, with prevalence rates varying from 10 to 50% and higher, depending upon the population and the definition of acute pain used (Chung & Wong, 2007; Hasselström et al., 2002; Koleva et al., 2005; Watkins et al., 2008). The prevalence of chronic pain is generally estimated between 10 and 35% (Blyth, March, Nicholas, & Cousins, 2003; Bouhassira, Lantéri-Minet, Attal, Laurent, & Touboul, 2008; Breivik et al., 2006; Català et al., 2002; Gureje et al., 1998; Saastamoinen et al., 2005; Toth et al., 2009; Verhaak, Kerssens, Dekker, Sorbi, & Besing, 1998). Back pain, headache, and leg pains appear to be most prevalent (Bassols, Bosch, Campillo, Cañellas,

& Baños, 1999; Breivik et al., 2006; Català et al., 2002; Chung & Wong, 2007; Gureje et al., 1998; Koleva et al., 2005; Watkins et al., 2008). Pain is more prevalent in women than men (Bassols et al., 1999; Bingefors & Isacson, 2004; Bouhassira et al., 2008; Català et al., 2002; Chung & Wong, 2007; Gureje et al., 1998; Koleva et al., 2005; Saastamoinen et al., 2005), and is found to increase with age (Ahacic & Kåreholt, 2010; Bassols et al., 1999; Bouhassira et al., 2008; Català et al., 2002; Chung & Wong, 2007; Tsang et al., 2008). The experience of pain can have a severe impact on daily life. Pain interferes with daily activities, and causes problems in the physical (e.g., loss of energy, fatigue, sleeping and concentration problems), emotional (e.g., depression, anxiety, low self-esteem), social (e.g., isolation, sexual and relationship problems) and financial domain (e.g., work loss, financial problems) (Bassols et al., 1999; Breivik et al., 2006; Català et al., 2002; Chung & Wong, 2007; Katz, Cooper, Walther, Sweeney, & Dworkin, 2004; Niv & Kreitler, 2001; Skevington, 1998). Higher levels of pain are associated with a poorer quality of life (Katz et al., 2004; Kovacs et al., 2004; Niv & Kreitler, 2001; Skevington, 1998).

In children and adolescents, pain is also commonly experienced, and is often the result of daily acitivies (e.g., sports, play, hobby), medical procedures (e.g., dentist, immunization) or disease (Finley, Franck, Grunau, & von Baeyer, 2005). Prevalence rates for acute and chronic pain show large variations across studies, with prevalence rates for acute pain varying from 25% to 90%, and for chronic pain varying from 25 to 45% (Huguet & Miro, 2008; Perquin et al., 2000; Roth-Isigkeit, Thyen, Raspe, Stöven, & Schmucker, 2004; Roth-Isigkeit, Thyen, Stöven, Schwarzenberger, & Schmucker, 2005). Pain experience increases with age (Martin, McGrath, Brown, & Katz, 2007; McGrath et al., 2000; Perquin et al., 2000; Roth-Isigkeit et al., 2004), and is more prevalent in girls than boys (Bakoula, Kapi, Veltsista, Kavadias, & Kolaitis, 2006; Hunfeld et al., 2001; Martin et al., 2007; Perquin et al., 2000). Stomach ache, headache and leg pains are most frequently reported (Huguet & Miro, 2008; Roth-Isigkeit, Thyen, Raspe, et al., 2004; Roth-Isigkeit, Thyen, Stöven et al., 2005; Sundblad, Saartok, & Engström, 2007). Pain is found to interfere with schoolwork and school attendance, and causes problems in the emotional (e.g., anxiety, depression), social (e.g., isolation, family problems), and physical domain (e.g., somatic complaints, sleeping difficulties) (Gauntlett-Gilbert & Eccleston, 2007; Martin et al., 2007; Palermo, 2000; Roth-Isighkeit et al., 2005; Sundblad et al., 2007). When a child experiences pain, this also affects the child’s family (e.g., parental distress, restricted social life of parents, financial problems) (Hunfeld et al., 2001; Sleed, Eccleston, Beecham, Knapp, & Jordan, 2005).

DISTRACTION

Distraction is an attentional pain coping strategy, in which attention is directed away from a noxious stimulus, and engaged in something else, such as other activities (behavioural distraction) or cognitions (cognitive distraction) (Eccleston, 1995b; Fernandez, 1986; Piira et al., 2002). This coping technique is often intuitively used in daily life (Leventhal, 1992), and is part of many pain treatment programs (Morley et al., 2004; Powers, 1999). Three theories are commonly used to explain the working mechanism of distraction.

A first theory is the limited attentional capacity theory. According to this theory attentional resource is limited (Broadbent, 1958; Kahneman, 1973; McCaul & Malott, 1984). When an attention-demanding distracting task is performed, pain and distraction task compete for available attentional resources. When the distraction task occupies all attentional resources, nociceptive stimuli will not be perceived, and less pain is experienced. Based on this theory it can be expected that distraction tasks which require more attentional resource (e.g., more difficult distraction tasks), are more effective in reducing pain. This prediction is supported by some studies, but is also refuted by several other studies (see Buhle & Wager, 2010 for an overview; Hodes, Howland, Lightfoot, & Cleeland, 1990; McCaul, Monson, & Maki, 1992; Seminowicz & Davis, 2007b), questioning the validity of this theory in explaining the effectiveness of distraction.

Second, the multiple resource theory, which questions the existence of a singular resource of information-processing by inferring the existence of three separate information-processing pools (Johnson, Breakwell, Douglas, & Humphries, 1998; Wickens, 1984). According to this theory, distraction tasks can be perceptual or behavioral, can require a verbal or manual (spatial) response, and can involve the visual, spatial or somatic modality. Only when two activities use the same pool of resources, they will compete for attentional resource and interfere with each other. Based on this theory it can be expected that distraction tasks that tap on the same resources as the pain (perceptual, spatial and somatic) are more efficient in diminishing pain. Little research is available testing this theory, so its usefulness in the field of distraction remains unclear (Johnson et al., 1998).

A final theory is the cognitive-motivational theory (Eccleston & Crombez, 1999; Legrain et al., 2009; Van Damme, Legrain, Vogt, & Crombez, 2010). This theory states that the attentional capture by pain - and as a result the effectiveness of distraction - depends upon the dynamic interplay between top-down and bottom-up influences. Examples of bottom-up influences are the characteristics of the pain (Eccleston & Crombez, 1999). Pain automatically captures attention when it is novel (Crombez, Baeyens, & Eelen, 1994; Legrain, Bruyer, Guérit, & Plaghki, 2005; Leventhal, Brown, Shacham, & Engquist, 1979), intense (Eccleston, 1994) and threatening (Crombez, Eccleston, Baeyens, & Eelen, 1998a; Van Damme, Crombez, Van-Nieuwenborgh-De Wever, & Goubert, 2008). It can therefore be expected that these bottom-up characteristics of the pain would hinder the distraction process, making it less effective. Examples of top-down processes are goal-pursuit and goal-shielding. When certain goals - for instance attending to the pain or performing a distraction task - are prioritized in working memory, this will result in the allocation of attention towards information that is important for the pursuit of these goals, while other information shall be inhibited (Fishbach & Ferguson, 2007; Goschke & Dreisbach, 2008; Shah, Friedman, & Kruglanski, 2002; Van Damme et al., 2010). In particular, when the distraction task becomes the prioritized goal, information that is important for the pursuit of this goal captures attention, resulting in the suppression of the pain processing. Processes that are involved in the pursuit of goals are attentional load and attentional set (Legrain et al., 2009). Attentional load refers to the amount of attention that is invested in a prioritized goal (Legrain et al., 2009). For instance, when the attentional load for a distraction task is high, the probability of goal-irrelevant stimuli to capture attention is low. In particular, when attention is invested in the distraction task as a primary goal, it is more difficult for pain stimuli to capture attention. Attentional set refers to the mental set of stimulus features that are used to identify of goal-relevant information (Legrain et al., 2009). When a stimulus matches the attentional set, attentional capture is facilitated. In particular, when the distraction task is the prioritized goal, stimuli that are important for performing this task will more easily capture attention. However, which goal is prioritized - attending to the pain or performing a distraction task - may differ between and within persons, depending upon the situation (Van Damme et al., 2010). Motivationally relevant distraction tasks may therefore be more effective in diminishing pain (Van Damme et al., 2010), because they are more likely to get prioritized over the processing of pain. Nevertheless, it is unlikely that the pain can ever be fully inhibited, and more likely that pain will always interfere with even the most successful distraction tasks. Distraction may therefore best be viewed as a process in which attention is dynamically switched between the pain and the distraction task. It is therefore reasonable to assume that distraction would be more effective in individuals who are able to rapidly switch attention back to the distraction task whenever the pain interferes.

Taken together, these different theories predict that distraction task engagement is probably the most important factor in the effectiveness of distraction. The distraction task should demand attention, and the degree to which it attracts attention might depend upon bottom-up characteristics of the pain, top-down influences, and possibly the degree to which the distraction task shares similar resources as the pain.

DISTRACTION EFFECTIVENESS

In adults, several reviews about the effectiveness of distraction exist (McCaul & Malott, 1984; Mullen & Suls, 1982; Suls & Fletcher, 1985; Wiederhold & Wiederhold, 2007; Wismeijer & Vingerhoets, 2005), but most of them are outdated, descriptive in nature, show weaknesses in the methodology employed, or are narrow in scope, as they only focus on one particular distraction strategy, such as virtual reality (e.g., Wiederhold & Wiederhold, 2007; Wismeijer & Vingerhoets, 2005). There is a strong need for meta-analytic research on distraction effectiveness in adults. In anticipation of such research, it can be concluded that individual studies have shown equivocal results. Several researchers have found beneficial effects of distraction (e.g., Campbell et al., 2010; Johnson et al., 1998; James & Hardardottir, 2002; Johnson & Petrie, 1997; Miron, Duncan, & Bushnell, 1989; Terkelsen, Andersen, Mølgaard, Hansen, & Jensen, 2004; Veldhuijzen, Kenemans, de Bruin, Olivier, & Volkerts, 2006), but others failed to demonstrate distraction effects (e.g., Hodes et al., 1990; McCaul et al., 1992), or found beneficial effects of distraction in some groups, but not in others (Unrod, Kassel, & Robinson, 2004). Some researchers even found counterproductive effects of distraction, with a slower recovery, or more pain after the painful stimulation (e.g., Buckelew et al., 1992; Cioffi & Holloway, 1993; Goubert, Crombez, Eccleston, & Devulder, 2004). Heterogeneous research findings may indicate that distraction is not effective for everyone in every situation.

Also in children and adolescents, several reviews on the effectiveness of distraction exist. For instance, Powers (1999) provided a descriptive overview of studies supporting the effectiveness of cognitive behavioral therapy packages in reducing procedural-related pain in children and adolescents. These packages include distraction strategies, but also other treatment components (e.g., breathing exercises, relaxation, cognitive coping strategies), making it difficult to conclude which components are responsible for the effect. Piira and colleagues (2002) employed a more narrow focus in their descriptive paper on the effectiveness of distraction in children’s acute pain management. These researchers concluded that empirical findings of distraction effectiveness are mixed, and made a plea for the methodological improvement of distraction studies. They also underlined the importance of investigating influencing factors of distraction effectiveness. Where the reviews of Piira and colleagues (2002) and Powers (1999) are descriptive in nature, Kleiber and Harper (1999) employed a meta-analytic approach when analyzing the effectiveness of distraction in children (3 to 15 years). Sixteen studies were included in the data analysis. Results showed small positive effects of distraction on children’s distress behavior. The effect of distraction on children’s self-reported pain was less clear. Results were highly variable across studies and are probably influenced by moderating variables (e.g., age, type of painful procedure). Results of these earlier reviews, however, should be interpreted with caution, because they are outdated, and focus on a large number of medical procedures varying in pain intensity and duration.

Recent systematic reviews on the effectiveness of distraction in children and adolescents employed a more narrow approach, where they focused on one particular medical procedure. For instance, DeMore and Cohen (2005) performed a systematic review on the effectiveness of distraction in pediatric immunization. Fifteen studies were included in the data analysis. Results showed that distraction was moderately effective in reducing pain during immunization in children aged 2 months to 8 years. Effects were generally situated on the behavioral observational measures of pain. More heterogeneous results were found for self-reported pain, distress, and physiological outcome measures, with only a minority of the studies reporting positive effects of distraction on these measures. Another systematic review on the effectiveness of distraction in pediatric immunization was performed by Chambers and colleagues (2009), who examined the effectiveness of a variety of psychological interventions, including distraction, in children aged 1 month to 11 years. A distinction was made between child-directed distraction (i.e., distraction directed at the child by means of a video, music, audiotape), and parent-led or nurse-led distraction (i.e., parent or nurse distract the child, for instance by using age appropriate toys). Results indicated a small positive effect of child-directed distraction on self-reported pain, but not on observer-rated pain or distress (N=3). Parent-led distraction was moderately effective in reducing observer-rated distress, but did not influence other measures of pain or distress (N=4). Small to moderate positive effects of nurse-led distraction were found on distress rated by the observer, the parent and the nurse (N=4), but heterogeneity between studies was substantial (I^2= 89 - 95%), so results should be interpreted with caution. Finally, Uman and colleagues (2008) performed a systematic review on the effectiveness of psychological interventions, including distraction, in needle-related procedural pain (e.g., immunization, venipuncture, finger prick, injections) in children and adolescents aged 2 to 19 years. Eleven studies were included in the data analysis. Results showed small positive effects of distraction on self-reported pain, but not on observer-reported distress, and behavioral measures of pain and distress.

In conclusion, most studies in children and adolescents report small to moderate positive effects of distraction (e.g., Dahlquist et al., 2009; Dahlquist et al., 2010; Miller, Rodger, Bucolo, Greer, & Kimble, 2010; Vessey et al., 1994; Wolitzky, Fivush, Zimand, Hodges, & Rothbaum, 2005). Nevertheless, effects are heterogeneous across pain outcome measures, with some studies finding positive effects of distraction on self-reported pain, and others finding no effects on self-reported pain. Similar heterogeneous results are found for physiological and behavioral measures, and measures of distress. Heterogeneous findings may indicate that distraction is not effective for everyone in every situation. Future research should therefore not focus on the question whether distraction is effective, but instead examine influencing factors of distraction effectiveness, in order to gaine more insight in the underlying processes of distraction effectiveness (Eccleston & Crombez, 1999; Kleiber & Harper, 1999; Piira et al., 2002). Research examining the role of influencing factors in the effectiveness of distraction in children and adolescents is, however, scarce (Piira et al., 2002).

INFLUENCING FACTORS OF DISTRACTION EFFECTIVENESS

Beliefs

According to Leventhal (1992), mixed research finding might partially be the result of people's intuitive common-sense beliefs about the effectiveness of distraction. It is reasonable to assume that distraction is found to be more effective in people who believe in its effectiveness. For instance, believers might show a larger motivation to engage in a distraction task than non-believers. It is also possible that distraction beliefs as such produce the pain relief. It has clearly been shown in the placebo literature that expectancy about the effectiveness of a pain reducing method can reduce the pain experience (de Jong, van Baast, Arntz, & Merchelbach, 1996; Sauro & Greenberg, 2005; Seminowicz, 2006).

Research investigating distraction beliefs is scarce. To our knowledge, only two studies examined distraction beliefs (Ahles & Blanchard, 1983; McCaul & Haugtvedt, 1982). Both studies reported a series of experiments in students, examining the effectiveness of distraction and sensory-focusing (i.e., attentional coping strategy, in which attention is focused on sensory elements of the pain thereby limiting affective processing of the pain). Additionally, beliefs about the effectiveness of these strategies were examined. Results of the Ahles and Blanchard study (1983) (N=28) showed that distraction is expected to diminish pain, where sensory-focusing is expected to increase the pain. Results of the McCaul and Haugtvedt study (1982) were less consistent. In a first experiment, students (N=45) were asked to imagine they were participating in a cold-pressor experiment. Students expected to be more distressed when they imagined using distraction during the immersion in cold water, and less distressed when they imagined using sensory-focusing. In a second study, students (N=30) first immersed their hand for 5 seconds in cold water to actually experience the stimulation. They were led to believe they would be participating in a cold-pressor experiment afterwards. Students reported they would prefer using distraction over sensory-focusing during the immersion in cold water. In conclusion, results of the Ahles and Blanchard (1983) and McCaul and Haugtvedt (1982) studies provide preliminary support for the existence of a common-sense distraction belief. Nevettheless, results need replication, as studies were not designed to measure beliefs as a primary goal, and used relatively small research samples. In children and adolescents, research investigating distraction beliefs is non-existent.

Pain catastrophizing

Cognitive-motivational models predict that distraction will be less effective when the pain is assessed as threatening (Eccleston & Crombez, 1999; Legrain et al., 2009). The degree to which pain is experienced as threatening may for instance depend upon individual differences in pain catastrophizing. People who catastrophize about pain show an exaggerated negative orientation towards actual or anticipated pain experiences (Sullivan, Bishop, & Pivik, 1995; Sullivan et al., 2001). They are hypervigilant to pain-related stimuli, and have more difficulty disengaging attention from pain (Crombez et al., 1998a; 1998b; Quartana, Campbell, & Edwards, 2009; Seminowicz & Davis, 2006; Van Damme, Crombez, & Eccleston, 2004). It can therefore be expected that it is more difficult for high catastrophizing individuals to engage in a distraction task during pain (Goubert et al., 2004; Van Damme et al., 2008), making distraction less effective. Preliminary findings support the negative association between catastrophizing and distraction effectiveness, but results need replication (Campbell et al., 2010; Goubert et al., 2004; Heyneman, Fremouw, Gano, Kirkland, & Heiden, 1990; Spanos, Radtke-Bodorik, Ferguson, & Jones, 1979).

In children and adolescents, research on pain catastrophizing is rather limited. Results are in line with adult research, and have shown that catastrophizing is associated with greater pain severity and disability (Crombez et al., 2003; Lynch, Kashikar-Zuck, Goldschneider, & Jones, 2006; Vervoort, Eccleston, Goubert, Buysse, & Crombez, 2010; Vervoort, Goubert, Eccleston, Bijttebier, & Crombez, 2006), and lower pain tolerance during a cold pressor test (Lu, Tsao, Myers, Kim, & Zeltzer, 2007; Piira, Taplin, Goodenough, & von Baeyer, 2002). Studies investigating the relationship between catastrophizing and distraction effectiveness are scarce, and the evidence is indirect. For instance, a questionnaire study in children with chronic pain investigated the relationship between pain catastrophizing and the effectiveness of coping strategies (Reid, Gilbert, & McGrath, 1998). This study has shown a negative association between pain catastrophizing and coping effectiveness, indicating that coping (i.e., coping in general, including distraction) is judged to be less effective with higher levels of pain catastrophizing (Lynch, Kashikar-Zuck, Goldschneider, & Jones, 2007). Indirect support is also provided by another questionnaire study, which examined the relationship between catastrophizing and personality traits in healthy schoolchildren (Muris et al., 2007). This study found a negative association between pain catastrophizing and attention control (i.e., ability to focus and shift attention), indicating that with higher levels of pain catastrophizing, lower levels of attention control are reported. As distraction is expected to be more effective in individuals with better attentional control abilities, it can be expected that distraction is less effective for high catastrophizing individuals. No studies in children and adolescents have addressed the relationship between catastrophizing and distraction effectiveness in a direct way.

Executive functioning

Executive functioning is an umbrella term which is used to describe complex cognitive processes that are important for the performance of daily life tasks, such as goal-shielding, planning, attentional control, problem-solving, self-regulation, organisation and reasoning (Funahashi, 2001; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000; Pineda et al., 1998; Smith & Jonides, 1999). Executive functioning is found to increase through childhood, with adult performance levels reached after the age of 12, and maturation still possible in adolescence (Cepeda, Kramer, & Gonzales de Sather, 2001; Huizinga, Dolan, & van der Molen, 2006; Romine & Reynolds, 2005). Research has pointed to the existence of three important executive functions (Fisk & Sharp, 2004; Huizinga et al., 2006; Lehto, Juujärvi, Kooistra, & Pulkkinen, 2004; Miyake et al., 2000). First, inhibition, described as the ability to inhibit dominant automatic or prepotent responses when necessary (Miyake et al., 2000). Research has shown that inhibition is not an unitary construct (Friedman & Miyake, 2004), but consists of at least three different constructs: Prepotent response inhibition (i.e., the ability to surpress habitual responses, Friedman & Miyake, 2004; cfr. behavioral inhibition, Nigg, 2000), resistance to distractor interference (i.e., the ability to inhibit information that is irrelevant for the task, Friedman & Miyake, 2004; cfr. interference control, Nigg, 2000), and resistance to proactive interference (i.e., the ability to inhibit information that was previously relevant but is not anymore, Friedman & Miyake, 2004; cfr. cognitive inhibition, Nigg, 2000). Response inhibition and resistance to distractor inhibition are interrelated, whereas resistance to proactive interference appears to be rather distinct (Friedman & Miyake, 2004). Second, task switching, which can be defined as the ability to shift back and forth between multiple tasks, operations or mental sets (Huizinga et al., 2006; Monsell, 1996; 2003). Third, working memory, defined as the updating and monitoring of working memory representations (Miyake et al., 2000). These three executive functions share a small common variance, but are generally considered to be unitary constructs (Huizinga et al., 2006; Miyake et al., 2000). Executive functions are supported by the prefrontal cortex (Homack & Riccio, 2004; Huizinga et al., 2006; Jurado & Rosselli, 2007), which is also part of the descending pain modulatory system that is involved in the attentional control of pain (Tracey & Mantyh, 2007; Wiech, Ploner, & Tracy, 2008). How executive functions might influence the pain experience remains to be investigated.

Recently, the involvement of executive functioning has been hypothesized in the effectiveness of distraction (Legrain et al., 2009). In order for distraction to be effective, people should be able to engage in the distraction task and inhibit the predominant response of attending and responding to the pain, and resist being interrupted by pain (Friedman & Miyake, 2004; Nigg, 2000). It can therefore be expected that distraction is more effective in people with good inhibition abilities. However, given its fundamentally aversive and interruptive character, it is unlikely that attention to pain can be fully inhibited (Eccleston & Crombez, 1999). Moreover, it can be expected that pain will regularly interfere with engagement in the distraction task (Eccleston, 1995a). Distraction may then be viewed as a process of the dynamic switching of attention between pain and the distraction task (Eccleston & Crombez, 1999). It can therefore be hypothesized that distraction is more effective for people with good task switching abilities as they should be more able to switch attention back to the distraction task whenever the pain interferes (Eccleston, 1995a). Finally, in order for distraction to be effective, people need to prioritize information in working memory that is relevant for the distraction task (Dalton, Lavie, & Spence, 2009a; 2009b; Dalton, Santangelo, & Spence, 2009; Lavie & de Fockert, 2005). Distraction should therefore be more effective in people with good working memory abilities. In sum, executive functioning, in particular inhibition, working memory and task switching may play a role in the effectiveness of distraction, but research investigating this hypothesis is scarce.

Existing research has mainly focussed on the role of working memory in the attentional control of pain (Legrain et al., 2009). Preliminary results have shown that less pain is experienced when distraction tasks are used which involve higher working memory capacity (Buhle & Wager, 2010). Results furthermore showed that working memory plays a role in visual (Dalton, Lavie et al., 2009b; Lavie & de Fockert, 2005), auditory (Dalton, Santangelo et al., 2009) and tactile attention (Dalton et al., 2009a). More precisely, working memory minimizes the interference of goal-irrelevant distracters. In children and adolescents, research on the relationship between executive functioning and distraction is non-existent.

METHODOLOGICAL CONSIDERATIONS IN DISTRACTION RESEARCH

Heterogeneous research findings, may be the result of moderating variables (e.g., beliefs, pain catastrophizing, executive functioning). They may also be the result of methodological weaknesses in distraction research designs, or methodological differences between studies (Eccleston, 1995b; Piira et al., 2002). It is important for future research to take into account these methodological considerations to gain more insight in the effectiveness of distraction.

Methodological pitfalls in distraction research

Many methodological weaknesses in distraction designs can be noted. These weaknesses can threaten the internal validity of studies, and can hinder the generalization of research findings, and should therefore be taken into account in future research (Eccleston, 1995b; Piira et al., 2002).

For instance, distraction studies often ask participants to indicate their experienced pain at different times during the painful stimulation (e.g., Jaaniste, Hayes, & von Baeyer, 2007; Meagher, Arnau, & Rhudy, 2001; Nouwen, Cloutier, Kappas, Warbrick, & Sheffield, 2006; Piira, Hayes, Goodenough, & von Baeyer, 2006). This is problematic as people are not able to direct their attention away from the pain, and at the same time pay attention to the pain and rate the pain experience. This paradoxical instruction puts pain within the attentional set, and might influence the distraction process (Eccleston, 1995b; Hadjistavropoulos & Craig, 2002). Future research should try to avoid interference between the pain measurement and the distraction process.

Also, many distraction studies use pain self-report as an outcome measurement of distraction effectiveness, but self-report can be subject to bias (Eccleston, 1995b; Hadjistavropoulos & Craig, 2002). For instance, the mere attendance of an experimenter (Sullivan, Adams, & Sullivan, 2004), and several characteristics of the experimenter (e.g., sex, status) can influence pain reports (Kállai, Barke, & Voss, 2004; Levine & De Simone, 1991). It can therefore be recommended to minimize the contact between the experimenter and participants. Pain reports can also be influenced by memory bias (Redelmeier, Katz, & Kahneman, 2003). Therefore, it is strongly recommended to minimize the interval between the painful stimulus and the pain report (Koyama, Koyama, Kroncke, & Coghill, 2004). Future research should try to minimize confounding influences when using pain self-report as an outcome measurement of distraction effectiveness.

Pain is often accompanied by emotions (e.g., anger, anxiety, sadness). As a result, the experience of pain cannot exclusively be described in terms of its bodily sensations. It is therefore necessary to measure both the sensory and the affective dimension of pain (Fernandez & Turk, 1992). Many studies fail to do so, and exclusively focus on the intensity of the pain. Also, pain is a very complex, multi-factorial experience, which is difficult to capture with one single item. The experience of pain should therefore preferably be assessed by using multiple items. Many distraction studies only use single item outcome measures.

Further, it is impossible to determine whether distraction is effective without using a proper control group. Many distraction studies do not include a control group. However, using a control group may also hold difficulties. For instance, it is possible that participants in the control group use spontaneous coping strategies (e.g., thinking of other things, counting) that might even be more effective than the experimental distraction. In light of the hypothesis under test, the use of spontaneous coping strategies in the control group might be a problem. The use of such strategies might be decreased by using instructions, but its use as such might also hold problems. For instance, the instruction to "focus on the stimulation" may as such produce pain relief, but its effect seems to disappear when the word "pain" is used (Leventhal et al., 1979). Future research should critically evaluate and clearly describe the instructions used in the control group.

Finally, many studies use distraction tasks without considering an underlying theoretical framework. This is problematic, because the processes underlying their effect (e.g. task difficulty, motivation, valence) may differ. Future research should carefully select the distraction task used, and report the underlying theoretical rationale. Further, most studies fail to check whether participants are indeed engaged in the distraction task (Eccleston, 1995b; Piira et al., 2002). Future research should use distraction tasks that allow an objective measurement of engagement, or at least provide subjective measurements of task engagement.

Methodological differences between studies

Distraction studies often differ in the methodologies employed. In order to critically evaluate study results, and allow a comparison of studies using different methodologies, it is important to provide a detailed description of the methodology employed.

For instance, distraction studies use a variety of pain induction methods (e.g., (cold) pressor pain, heat stimulation, capsaicin gel, electrical stimulation). However, the pain quality and quantity provoked by these different pain inducing methods greatly differs (Janal, Glusman, Kuhl, & Clark, 1994; Hastie et al., 2005), making a comparison across studies difficult. Even when the same pain inducing method is used, comparison across studies might be difficult. For instance, many distraction studies use the cold pressor task (CPT), a safe method, which generally causes no adverse physical or psychological side effects (Lovallo, 1975; von Baeyer, Piira, Chambers, Trapanotto, & Zeltzer, 2005). The cold pressor task requires people to immerse a hand, foot or limb in cold water for a certain period of time. This provokes a painful stimulation, which is comparable with clinical pain (von Baeyer et al., 2005). Pain experience largely depends upon the water temperature used (LeBaron, Zeltzer, & Fanurik, 1989; Mitchel, MacDonald, & Brodie, 2004). Research, however has used large variations in water temperatures varying from 0 °C to 7 °C and higher, making a comparison of studies using different temperatures difficult. The pain experience can also be influenced by the immersion duration. The cold pressor test is very painful in the beginning, after a few minutes the pain decreases, to increase again after a while (Eccleston, 1995b). Research however, has used very different immersion intervals. Most researchers instruct participants to immerse their hand until the stimulation is unbearable (tolerance paradigm). In this research paradigm "time" is the dependent variable. Others instruct participants to immerse their hand for a fixed period of time (fixed interval paradigm). In this research paradigm, the "pain experience" is the dependent variable. It is difficult to compare studies using these different research paradigms. The pain experience can also be influenced by other factors, such as the use of a circulation water pump, the immersion of the wrist, the immersion instructions used, the standardization of the hand temperature before immersion, etc. (von Baeyer et al., 2005). It is often unclear whether these factors are taken into account in previous research, making a comparison across studies difficult. In order to compare distraction studies using the cold pressor task, it is important to provide a detailed description of how the CPT is used (e.g., temperature, immersion interval, instructions, etc.). It is also important to critically consider the use of the CPT and its parameters in function of the hypothesis under test.

Also, a variety of distraction tasks is used across studies (Eccleston, 1995b), such as imagery (e.g. Huth, Broome, & Good, 2004; Jaaniste et al., 2007; Piira et al., 2006), listening to music (e.g., Arts et al., 1994), auditory detection tasks (e.g., Goubert et al., 2004; Van Damme et al., 2008), viewing pictures (e.g., de Wied & Verbaten, 2001; Meagher et al., 2001; Rhudy, Williams, McCabe, Russell, & Maynard, 2008), smelling odors (e.g., Marchand & Arsenault, 2002), video watching (e.g., Cassidy et al., 2002), virtual reality (e.g., Dahlquist et al., 2007; Dahlquist et al., 2009; Dahlquist et al., 2010; Magora, Cohen, Shochina, & Dayan, 2006), playing video games (e.g., Campbell et al., 2010). Nevertheless, these distraction methods may differ in the degree to which they demand attention. It might therefore be recommended to provide a measurement of distraction task engagement to compare studies using different distraction tasks.

Distraction studies also use a variety of pain measurements (e.g., physiological measurements, facial pain expression, self-report, observer-report). It is important to note that these measurements assess other aspects of the pain, and are therefore difficult to compare (Eccleston, 1995b).

Finally, studies have used very different instructions. As instructions might impact study results (Eccleston, 1995b), it is difficult to critically evaluate the study design, and compare studies, without taken into account the instructions used. Nevertheless, instructions are often not reported. Future research should certainly report the instructions employed in detail.

SUMMARY

Pain occurs frequently, and can have a severe impact on daily life. Research on pain reducing methods is therefore important. Distraction is an attentional strategy to cope with pain, which is often intuitively used, and is part of many pain treatment programs. Research about the effectiveness of distraction, however, shows heterogeneous results. These results may partially be the result of methodological problems in research designs and methodological differences between studies. Heterogeneous findings, however may also point to the role of influencing factors of distraction effectiveness. Future distraction research should try to avoid methodological pitfalls in previous research designs, and should investigate the role of influencing factors of distraction effectiveness, such as beliefs, catastrophizing and executive functioning.

OUTLINE OF DISSERTATION

The objectives of this dissertation are threefold. First, distraction beliefs were examined in students and schoolchildren to explore how this research population generally thinks about distraction as a pain coping technique. Second, a distraction paradigm was developed, with takes into consideration the methodological pitfalls of previous distraction research. Finally, this distraction paradigm was used to investigate the influencing role of pain catastrophizing and executive functioning on distraction effectiveness in both students and schoolchildren. This dissertation consists of four major parts, comprising nine studies, divided into six chapters.

Part I, which comprises **CHAPTER 1**, consists of two vignette studies, in which the beliefs about the effectiveness of distraction were investigated in students (*N*=263) (**study 1**), and schoolchildren (*N*=617) (**study 2**). Participants were presented hypothetical painful situations, in which the pain intensity, pain threat and pain novelty were manipulated. They indicated the degree to which they believed distraction would be effective to diminish pain in the presented situation. The moderating role of pain catastrophizing was also examined. In the second study, we also explored beliefs about the effectiveness of sensory-focusing.

Part II, which composes **CHAPTER 2**, consists of two pilot studies examining the effectiveness of distraction in students (**study 3**: *N*=39; **study 4**: *N*=93). A cold pressor paradigm was used, which has taken into account many of the methodological problems in earlier distraction research.

Part III, which contains **CHAPTER 3** and **CHAPTER 4**, examines the relationship between pain catastrophizing and distraction. In **CHAPTER 3**, the cold pressor paradigm was optimized, and used to examine the influencing role of pain catastrophizing in the effectiveness of distraction in a student population (*N*=73) (**study 5**). In **CHAPTER 4**, the relationship between pain catastrophizing and distraction was examined in schoolchildren. Participants first participated in a questionnaire study (N=828), which examined the use of distraction in daily life (**study 6**), and subsequently participated in a cold pressor experiment (N=81) (**study 7**).

Part IV, which consists of **CHAPTER 5** and **CHAPTER 6**, investigates the impact of executive functioning on distraction effectiveness. In **CHAPTER 5**, the cold pressor paradigm was used to examine the influencing role of inhibition, task switching and working memory in the effectiveness of distraction in a student population (*N*=91) (**study 8**). In **CHAPTER 6**, the relationship between executive functioning and distraction was examined in schoolchildren (*N*=162) (**study 9**).

In a general discussion, the main results of the different studies are critically discussed. Implications for distraction theory, clinical practice and experimental research are discussed. Finally, limitations and avenues for future research are outlined.

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CHAPTER 1

YOUNG PEOPLES BELIEFS ABOUT ATTENTIONAL STRATEGIES TO CONTROL PAIN: A VIGNETTE APPROACH[1]

ABSTRACT

Attentional strategies are often used to cope with pain, and are part of many pain treatment programs. Preference for a strategy and adherence to it are thought to depend upon beliefs about effectiveness. This research examines beliefs about the effectiveness of attentional pain coping strategies (i.e., distraction and sensory-focusing). Beliefs are usually influenced by situational and individual factors, therefore we also examined whether effectiveness beliefs would depend upon characteristics of the pain situation (threat, intensity, novelty) and pain catastrophizing. Research questions were examined in two separate vignette studies, one in university students (*N*=263), and one in schoolchildren (*N*=617). Results showed that participants believed distraction to be moderately effective in diminishing pain. However, students as well as schoolchildren believed distraction to be less effective in situations in which the pain is experienced as threatening. Students also believed distraction to be less effective in situations of intense pain. Pain novelty did not influence distraction beliefs. Results were independent of the level of pain catastrophizing. Furthermore, results indicated that schoolchildren failed to understand the notion of sensory-focusing. They did not believe in its effectiveness and rarely use this technique in daily life. Beliefs regarding the effectiveness of sensory-focusing were independent of characteristics of the pain situation or individual difference variables. Clinical implications are discussed.

[1] Verhoeven, K., Goubert, L., Eccleston, C., Van den Bussche, E., & Crombez, G. (submitted). Young peoples beliefs about attentional strategies to control pain: A vignette approach.

INTRODUCTION

Attentional coping strategies are often employed when attempting to cope with pain. Indeed, distraction, or directing attention away from pain, is a near ubiquitous method for trying to endure any short lived adversity (Morley, Shapiro, & Biggs, 2004; Powers, 1999). The empirical evidence for the effectiveness of distraction, however, is equivocal (Seminowicz & Davis, 2007; Van Damme, Legrain, Vogt, & Crombez, 2010), with some studies finding beneficial effects of distraction on pain reduction (e.g., James & Hardardottir, 2002; Johnson, Breakwell, Douglas, & Humphries, 1998; Kleiber & Harper, 1999; Marchand & Arsenault, 2002; McCaul & Haugtvedt, 1982; Uman, Chambers, McGrath, & Kisley, 2008; Vessey, Carlson, & McGill, 1994), but others finding no effects (e.g., Arts et al., 1994; Carlson, Broome, & Vessey, 2000; Cassidy et al., 2002; Jaaniste, Hayes, & von Baeyer, 2007; Manne, Redd, Jacobsen, Gorfinkle, & Schorr, 1990; McCaul, Monson, & Maki, 1992) or even counterproductive effects (e.g., Cioffi & Holloway, 1993; Goubert, Crombez, Eccleston, & Devulder, 2004). This indicates that distraction might not be effective for everyone in every situation (Eccleston & Crombez, 1999).

The preference for a treatment strategy, and adherence to the chosen strategy, depends upon the beliefs people have about illness (e.g., pain) and treatment (Horne, 1999; Horne & Weinman, 2002). It can therefore be assumed that the preference for distraction is based upon people’s beliefs about its effectiveness. Leventhal (1992) argued that people have strong beliefs about the effectiveness of distraction, that are unrelated to the actual effectiveness of this technique. The existence of such a common-sense distraction belief may not only result in the persistent use of distraction in situations in which distraction is ineffective, it may also prevent the adoption of other pain coping strategies that might be more successful in certain situations. It is however unclear whether such a common-sense distraction belief actually exists. To our knowledge, only two relatively small sample studies have examined beliefs about distraction in students (Ahles & Blanchard, 1983; McCaul & Haugtvedt, 1982). These studies, however, were not designed to investigate distraction beliefs as a primary goal. Results showed that distraction is preferred to sensory-focusing, an attentional strategy in which attention is focussed on sensory elements of the pain thereby limiting the processing of negative affective elements of the pain (Piira, Hayes, Goodenough, & von Baeyer, 2006; Quartana, Burns, & Lofland, 2007). It remains to be seen whether these results can be replicated, and whether they generalize to other populations. In children, no research on distraction and sensory-focusing beliefs exists. Children's beliefs are likely to be different from those of students, making a comparison interesting.

Beliefs are often very specific and are likely to depend upon situational and individual characteristics. However, little is known about factors that might influence distraction beliefs. Cognitive-motivational models of attention to pain provide theoretical guidance on the relationship between pain, attention, and its influencing factors (Eccleston & Crombez, 1999; Legrain et al., 2009; Leventhal, 1992). Based on these models it can be expected that distraction is more effective when the distraction task has an emotional significance (Leventhal, 1992), and is less effective in situations in which the pain is novel, intense and experienced as threatening, because pain automatically attracts attention in these situations (Crombez, Baeyens, & Eelen, 1994; Crombez, Eccleston, Baeyens, & Eelen, 1998a; 1998b; Eccleston, 1994; Van Damme, Crombez, Van Nieuwenborgh-De wever, & Goubert, 2008). It is unknown whether people also have beliefs about distraction specific to these situations. Furthermore, it can be expected that distraction is less effective for high catastrophizing individuals (i.e., those with an exaggerated negative orientation towards actual or anticipated pain experiences), as they are more likely to experience painful situations as highly threatening (Sullivan, Bishop & Pivik, 1995). There are no data on the influence of catastrophic thinking on distraction beliefs.

The primary aim of this research was to examine beliefs about the effectiveness of attentional strategies for the management of pain, in particular distraction. Further, the study was designed to examine whether characteristics of the pain situation or individual differences in pain catastrophizing would influence these beliefs. A vignette methodology was selected, because vignettes are commonly used to examine complex beliefs, can identify factors that contribute to these beliefs, and have been successfully used with children and students (Alexander & Becker, 1978; Veenma, Batenburg, & Breedveld, 2004). Two samples were employed in two separate studies: First a sample of university students (*N*=263) was selected to replicate and extend previous research findings, and second a sample of schoolchildren (*N*=617) was recruited to explore whether beliefs would differ in samples of different ages. In the second sample, we also explored beliefs about the effectiveness of sensory-focusing.

STUDY 1

AIMS

This study was designed to investigate common-sense distraction beliefs in a sample of university students. The effects of pain characteristics, distraction task characteristics, and pain catastrophizing were also examined. We hypothesized that the strength of participants' distraction beliefs would be lower when the pain is intense, threatening, and novel, and when the distraction task has an internal (imagery), rather than an external (social contact) focus. The second aim was to investigate whether distraction beliefs are influenced by the level of catastrophic thinking about the pain. Specifically, we hypothesized that the strength of participants' distraction beliefs would decrease with higher levels of pain catastrophizing.

METHOD

Participants

Two hundred sixty-three psychology students (227 females, M_{age}=19.92, *SD*=1.74, range 18-24 years) from Ghent University (Belgium) participated in this study. No specific inclusion or exclusion criteria were specified.

Measures

Participant characteristics

Pain severity was assessed with the 3-item subscale of the Dutch version of the Multidimensional Pain Inventory (MPI; Kerns, Turk, & Rhudy, 1985; MPI-DLV; Lousberg et al., 1999). The MPI-DLV assesses the psychosocial and behavioural aspects of the pain experience and has good psychometric qualities (Lousberg, Schmidt, Groenman, Vendrig, & Dijkman-Caes, 1997). Participants have to indicate the present pain, and the pain and disability they experienced in the past week. Responses are given on a 7-point Likert scale (0="no pain/interference", 6="a lot of pain/interference"). Cronbach's alpha of the pain severity scale in the current study was .80.

Distraction beliefs

A vignette paradigm was used to examine the strength of participants' distraction beliefs. Using the theoretical guidelines of Veenma and colleagues (2004), vignettes describing hypothetical pain situations, were developed in collaboration with several vignette experts. The vignettes were pre-tested on 10 volunteers, who matched the research population. Based on their comments, the vignettes were finalized. Examples of the vignettes used in study 1 are presented in appendix 1.

Characteristics of the pain were manipulated in a 2 x 2 x 2 x 2 within-subjects design: Pain intensity and pain threat were coded as low (0) versus high (1); pain novelty as familiar (0) versus novel (1); and distraction type as positive imagery (0) versus social contact (1). To ensure that possible effects would not be attributable to one type of pain situation, 16 different pain contexts were used, that were recognizable to students (e.g., a headache from a hangover, a stomach ache before an exam). In total 256 vignettes were created, in which each (2x2x2x2)-factor combination was combined with each of the 16 pain contexts. These 256 vignettes were divided over 16 booklets, so that each booklet contained 16 different pain situations and each (2x2x2x2)-factor combination occurred once. Participants completed one booklet with 16 vignettes. Participants were asked to imagine each of the 16 pain situations in the booklet as vividly as possible, and to indicate on a 5-point scale the extent to which they believed distraction would be effective in diminishing pain in the particular pain situation (1="not at all effective"; 2="rather not effective"; 3="moderately effective"; 4="somewhat effective"; 5="very effective"). A distinction was made between personal distraction beliefs (e.g., "it is effective to diminish my pain") and general distraction beliefs (e.g., "it is effective for people in general to diminish their pain"), because we assumed that participants' beliefs about the effectiveness of distraction could differ for themselves and others.

Pain catastrophizing

Pain catastrophizing was assessed with the Dutch version of the Pain Catastrophizing Scale (PCS; Crombez et al., 1998b; Sullivan et al., 1995). Participants have to indicate on a 5-point scale the extent to which they experience catastrophic thoughts and feelings when they are in pain (0="not at all", 4="always"). The PCS is a 13-item scale (e.g., "I can't seem to keep the pain out of my thoughts"), with total scores ranging from 0 to 52. The Dutch version has shown good reliability and validity in both student and clinical populations (Van Damme, Crombez, Bijttebier, Goubert, & Van Houdenhove, 2002). In this study, Cronbach's alpha was .87.

Procedure

Participants were recruited at the end of a course by research assistants. They were informed about the study at the beginning of the course and voluntarily stayed after class to complete an informed consent form, the PCS, the MPI and the vignettes. The 16 different vignette booklets were distributed randomly. Participation took about 20 minutes.

Data analysis

Data were analyzed using SPSS 15.0. First, we investigated whether distraction beliefs were influenced by pain characteristics and distraction task characteristics, by means of ANOVA repeated measures analyses. Participants' beliefs about distraction were entered as the dependent variable, and pain intensity, novelty, threat and distraction type as within-subjects factors. Repeated measures analyses were performed separately for personal and general distraction beliefs. Second, catastrophizing was added as a covariate and the analyses were repeated to examine whether the effects of pain and distraction task characteristics on distraction beliefs were moderated by the level of catastrophic thinking. As recommended by Van Breukelen and Van Dijk (2007), the covariate was centred. Wilks' Lambda *F*-scores were used. Cohen's *d* was calculated to determine whether results had a small (0.15), medium (0.40) or large (0.75) effect size (Cohen, 1988).

RESULTS

Sample characteristics

The majority of the participants reported no pain (55%) or minimal pain (26%) at the moment of testing. The pain experienced the week prior to the testing was of low intensity (*M*=1.79, *SD*=1.30, range 0-6) and was associated with little disability (*M*=1.80, *SD*=1.53, range 0-6).

Distraction effectiveness beliefs

A "total belief score" about the effectiveness of distraction was created by averaging the distraction belief scores for all (2x2x2x2)-factor combinations separately for personal beliefs (Cronbach's alpha=.75) and general beliefs (Cronbach's alpha=.76). Distraction was believed to be moderately effective. A paired-samples *t*-test showed that participants believed that distraction was more effective for others (*M*=3.07, *SD*=0.40), than for themselves (*M*=3.02, *SD*=0.47) ($t(262)=2.94$, $p<.01$, $d=0.18$).

Repeated measures analyses were performed. Means and standard deviations of personal and general distraction beliefs are presented in Table 1. Results showed that participants believed that distraction is less effective for themselves and others when the pain is experienced as threatening (all $F>362$, $p<.001$, $d>1.16$) and intense (all $F>36$, $p<.001$, $d>0.39$). Pain novelty did not influence distraction beliefs (all $F<1$, $p>.10$, $d<0.06$). Distraction beliefs were furthermore influenced by the distraction type, indicating that social contact is believed to be more effective as a distractor than positive imagery (all $F>9$, $p<.01$, $d>0.19$). A significant interaction-effect of (distraction type x threat), however, showed that this effect was present only when the pain was experienced as threatening (all $F>4.8$, $p<.05$).

Table 1

Means (M) and standard deviations (SD) of personal and general beliefs about the effectiveness of distraction in study 1 (N=263)

		M (SD)		F (1,262)
Personal beliefs	**Pain intensity**	*Low*	*High*	
		3.13 (0.54)	2.91 (0.54)	48.06***
	Novelty	*Novel*	*Familiar*	
		3.03 (0.51)	3.01 (0.53)	0.62
	Pain threat	*Low*	*High*	
		3.34 (0.55)	2.70 (0.53)	400.95***
	Distraction type	*Social contact*	*Positive imagery*	
		3.07 (0.53)	2.97 (0.55)	9.34**
General beliefs	**Pain intensity**	*Low*	*High*	
		3.15 (0.45)	2.99 (0.45)	36.93***
	Novelty	*Novel*	*Familiar*	
		3.06 (0.44)	3.08 (0.45)	0.43
	Pain threat	*Low*	*High*	
		3.36 (0.48)	2.79 (0.46)	362.47***
	Distraction type	*Social contact*	*Positive imagery*	
		3.12 (0.46)	3.02 (0.46)	12.83***

*p<.05; **p<.01; *** p<.001.

Pain catastrophizing

Total scores for personal and general distraction beliefs were subtracted and correlated with catastrophizing. Catastrophizing was found to be significantly correlated with the difference score (r=-.36, p<.001). The more participants catastrophize about pain, the more they believe distraction is less effective for themselves than for others.

To test whether the effects of pain and distraction task characteristics on distraction beliefs were moderated by the level of catastrophic thinking, repeated measures analyses were performed with catastrophizing entered as a covariate. Results showed no interaction-effects of (catastrophizing x pain characteristics) or (catastrophizing x distraction task characteristics) on personal or general distraction beliefs (all F<1, p>.10).

DISCUSSION

This study indicated that distraction is believed to be moderately effective in diminishing pain. Distraction beliefs are influenced by situational factors. For instance, participants believed distraction to be less effective in threatening and intense pain situations. In threatening pain situations participants believed that social contact is a better distracter than the use of positive imagery. Pain novelty did not influence distraction beliefs. The impact of pain characteristics on distraction beliefs was independent of the level of pain catastrophizing. Catastrophizing did however influence distraction beliefs. The higher the level of catastrophizing, the more participants believed distraction to be less effective for themselves than for others.

STUDY 2

AIMS

In this second study, we aimed to replicate the findings of study 1 in a younger population. The role of pain characteristics and pain catastrophizing was also investigated. There are some differences to study 1. We asked participants about their beliefs about the effectiveness of distraction and did not make a distinction between personal and general distraction beliefs, because we believed it would be too difficult for younger children to differentiate between themselves and the world in general. We did not incorporate different types of distraction, because we wanted to make the vignettes more compact and easier to imagine for younger children. In this study we also explored the beliefs about the effectiveness of sensory-focusing, an attentional strategy which is sometimes used as a counterpart of distraction in experiments with children (Fanurik, Zeltzer, Roberts, & Blount, 1993; Piira et al., 2006; Tsao, Fanurik, & Zeltzer, 2003). In students, evidence indicates that the efficacy of sensory-focusing is counter-intuitive (Ahles & Blanchard, 1983). It is currently unknown whether this is also the case in children. It is not clear whether children understand the meaning of this technique, whether they use sensory-focusing in their daily lives, and what their thoughts are about the effectiveness of this technique.

METHOD

Participants

Fifteen elementary and high schools were contacted in Ghent (Belgium). Six schools, with a total school population of 1530 children, agreed to participate. The main reason for schools refusing to participate was "lack of time". Children were allowed to participate if signed parental inform consent and child assent were obtained. Of the 1530 children and parents approached, 43% agreed to participate (*N*=660). An equal number of children did not return the informed consent form, and 14% refused to participate. Ninety-three percent of those agreeing, actually participated (*N*=617, 332 girls, M_{age}=12.57, *SD*=2.43, age range 8-18). Illness was the most common reason for declining. In the lower grades 11.8% of the children were recruited from grade 4 (*N*=73), 11.3% from grade 5 (*N*=70) and 14.7% from grade 6 (*N*=91). In the higher grades, 10% of the children were recruited from grade 7 (*N*=62), 14.4% from grade 8 (*N*=89), 14.7% from grade 9 (*N*=91), 11.2% from grade 10 (*N*=69), 5.8% from grade 11 (*N*=36) and 5.8% from grade 12 (*N*=36). No specific inclusion and exclusion criteria were specified.

Participants were randomly assigned to either a distraction group *(N*=326, 180 girls, M_{age}=12.76, *SD*=2.67), in which the beliefs about the effectiveness of distraction were examined, or a sensory-focusing group (*N*=291, 152 girls, M_{age}=12.35, *SD*=2.12), in which the beliefs about the effectiveness of sensory-focusing were examined.

Measures

Participant characteristics

Participants' pain characteristics were assessed with six items that are based on the Varni-Thompson Pediatric Pain Questionnaire (PPQ; Varni, Thompson, & Hanson, 1987). Participants indicated whether they had experienced pain during the past two weeks. If this question was answered affirmatively, they were asked to indicate the pain locations on a manikin figure. Pain intensity (0="a little bit" to 3="very much") and frequency (0="once" to 3="all the time") were also assessed. Finally, participants indicated on a 100 mm VAS the worst pain they experienced during the past two weeks, and the present pain (0="no pain", 100="very much pain").

Distraction and sensory-focusing beliefs

Prior to the vignettes, a definition was presented to check participants' understanding of the distraction or sensory-focusing technique. Definitions are presented in appendix 3. Participants were asked to indicate whether they understood this definition (yes/no). Furthermore, participants indicated on a 5-point scale the extent to which they use distraction or sensory-focusing in their daily lives (0="never" to 4="always"), and the degree to which they believe this technique is effective in diminishing pain (0="not at all effective" to 4="very effective"). They were also asked to formulate an example of how they use this technique in their daily life (open question). Vignettes were developed in a similar way as in study 1, and were adapted to the population of schoolchildren. Vignettes were refined in debate with experts in the field of health psychology and pre-tested on six children of the youngest age group to test comprehensiveness, language and layout. Based on their comments the vignettes were finalized. Appendix 2 shows examples of the vignettes used in study 2. To investigate the hypotheses, characteristics of the pain situation were manipulated in a 2 x 2 x 2 within-subjects design: Pain intensity and pain threat were coded as low (0) versus high (1); pain novelty as novel (0) versus familiar (1). To avoid possible effects being attributable to one type of pain situation, eight different pain contexts were used that often occur in this population (Perquin et al., 2000), and are recognizable to children (e.g., an injury during gym class). In total, 64 vignettes were created, in which each (2x2x2)-factor combination was combined with each of the eight pain contexts. These 64 vignettes were divided over eight booklets, so that each booklet contained eight different pain situations and each of the (2x2x2)-factor combination occurred once. Participants completed one booklet with eight vignettes.

We used two vignette versions: A distraction version and a sensory-focusing version. Participants indicated on a 5-point scale the extent to which they believed distraction or sensory-focusing, is effective in reducing pain in the particular pain situation (1="not at all effective"; 2="somewhat effective"; 3="fairly effective"; 4="quite effective"; 5="very effective").

Pain catastrophizing

Pain catastrophizing was measured with the Dutch version of the Pain Catastrophizing Scale for Children (PCS-C; Crombez et al., 2003). This questionnaire is an adapted version of the adult Pain Catastrophizing Scale (Sullivan et al., 1995). The PCS-C consists of 13-items (e.g., "when I'm in pain, I'm afraid the pain will get worse"), measuring the frequency of catastrophic thoughts and feelings during pain on a 5-point scale (0="not at all", 4="very much"). Total scores range from 0 to 52. Research has shown that the PCS-C is reliable and valid for children aged 9 to 15 years (Crombez et al., 2003). In this study, Cronbach's alpha was .87.

Procedure

Schools were first contacted by letter, then by phone. When the principal gave consent for this study to take place, parents were given a letter explaining the purpose of this study, including an informed consent form. Children were allowed to participate if signed parental informed consent and child assent were obtained. Questionnaires and vignettes were administered in the classroom, during the regular school hours, in the presence of a research assistant. Participants received information about the study at the beginning of the test session. They were informed that they could stop the test at any time and that their answers would be treated confidentially. Instructions were presented at the top of each questionnaire, complemented with oral clarification by the research assistant. Completion of the questionnaires took about 30 minutes.

Data analysis

For data analysis SPSS 15.0 was used. First, the comprehension of the distraction and sensory-focusing definitions, the use of both techniques in daily life, and the general effectiveness beliefs were analyzed with descriptive analyses. Second, we examined whether participants' beliefs where influenced by pain characteristics. We used two ANOVA repeated measures analyses, in which distraction or sensory-focusing beliefs were entered as the dependent variable, and the pain characteristics (pain intensity, novelty, and threat) as within-subjects factors. We also controlled for age and sex. Finally, we examined the relationship between catastrophizing and the beliefs about the effectiveness of distraction and sensory-focusing, by means of Pearson correlation analyses. To test whether pain catastrophizing moderated the effects of pain characteristics on distraction or sensory-focusing beliefs, the analyses were repeated after entering catastrophizing as a covariate. Similar to study 1, the covariates were centered (Van Breukelen & Van Dijck, 2007), *F*-scores are based on Wilks' Lambda, and Cohen's *d* was calculated to determine effect sizes (Cohen, 1988).

RESULTS

Sample characteristics

Eighty-seven percent of the children experienced pain during the two weeks prior to the study. The pain was described as mildly intense (M=1.02, SD=0.80, range 0-3). Leg pain (41%), headache (31%) and pain in other parts of the body (e.g., feet, hands or neck) (55%) were most frequently reported. The majority reported having experienced pain once (24%) or a few times (56%) during the past two weeks. At the moment of testing, 25% reported being pain free, most participants reported low intense pain (M=26.80, SD=24.48, range 0-100). No differences were found between the distraction and the sensory-focusing group in pain experience prior to the testing ($\chi 2(1)=0.28$, $p>.10$) and in the present pain experience ($t(577)=1.61$, $p>.10$, $d=0.13$).

Distraction beliefs

Descriptives

The majority of the participants (99%) reported that they understood the presented distraction definition (N=322). Content analyses showed that only 3% provided an incorrect example of the use of distraction in daily life (e.g., focus on pain, take medication). Comprehension of the distraction technique was high and comparable in the three age categories (respectively 8-11 years: 93%; 12-14 years: 98%; 15-18 years: 97%, $\chi 2(2)=3.65$, $p>.10$). Participants who did not comprehend the distraction technique were removed from further analyses. Of the 313 remaining participants (174 girls), 3.5% reported never using this technique in daily life. The majority reported using this technique, sometimes (44%), often (27%), a lot (17%) or always (8%). Five percent believed that this technique is not effective in diminishing pain. The majority believed that this technique was somewhat effective (44%), quite effective (26%), effective (18%) or very effective (7%). The use of this technique was negatively correlated with age (*r*=-.17, *p*<.01). Boys and girls reported using this technique equally often (M_{girls}=1.78, *SD*=0.93; M_{boys}=1.88, *SD*=1.13; *t*(264)=-0.88, *p*>.10, *d*=0.10). The use of distraction was positively correlated with the perceived effectiveness (*r*=.50, *p*<.001). Perceived effectiveness was not correlated with age (*r*=-.09, *p*>.10) and was similar in boys and girls (M_{girls}=1.74, *SD*=0.99; M_{boys}=1.83, *SD*=1.07; *t*(306)=-0.73, *p*>.10, *d*=0.09). This indicates that regardless of the child's age or sex, the use of distraction was related to its believed effectiveness.

Impact of pain characteristics

To examine whether characteristics of the pain situation influenced distraction beliefs, repeated measures analyses were performed. Means and standard deviations are presented in Table 2. Results indicated that distraction was believed to be less effective when pain was threatening (*F*(1,297)= 5.71, *p*<.05, *d*=0.14). Distraction beliefs were not influenced by pain intensity (*F*(1,297)=1.32, *p*>.10, *d*=0.09) or pain novelty (*F*(1,297)=0.63, *p*>.10, *d*=0.06). Results were not influenced by age or sex (all *F*<1, *p*>.10).

Table 2

Means (M) and standard deviations (SD) of the beliefs about the effectiveness of distraction and sensory-focusing in study 2 (N=617)

		M (SD)		F (1,297)
Distraction beliefs	**Pain intensity**	*Low*	*High*	
		1.49 (0.82)	1.43 (0.81)	1.32
	Novelty	*Novel*	*Familiar*	
		1.44 (0.79)	1.48 (0.84)	0.63
	Pain threat	*Low*	*High*	
		1.51 (0.85)	1.41 (0.81)	5.71*
		M (SD)		**F (1,65)**
Sensory-focusing beliefs	**Pain intensity**	*Low*	*High*	
		0.53 (0.54)	0.53 (0.54)	0.10
	Novelty	*Novel*	*Familiar*	
		0.54 (0.59)	0.51 (0.53)	0.80
	Pain threat	*Low*	*High*	
		0.52 (0.59)	0.54 (0.55)	0.04

**p*<.05.

Sensory-focusing beliefs

Descriptives

The majority of the participants (94%) reported that they understood the sensory-focusing definition presented (N=271). However, content analyses showed that 70% provided a wrong example of the use of the sensory-focusing technique in daily life (e.g., watch TV, go to the doctor, take medicines), indicating that participants did not comprehend the notion of sensory-focusing. Comprehension rates were low, with the highest comprehension rate in the oldest age group (8-11 years: 24.8%; 12-14 years: 23.5%; 15-18 years: 31%; $\chi 2(2)=0.95$, $p>.10$). Participants who did not understand the sensory-focusing technique were removed from further analyses. Of the 73 remaining participants (39 girls), 77% reported never using this technique in daily life, 21% reported using this technique sometimes. Only a small number reported using this technique often (3%). The majority believed that this technique was not effective (42%), or only to a small extent effective in diminishing pain (51%). The use of this technique tended to be positively correlated with age (r=.22, p=.07), and was used equally by boys and girls (M_{girls}=0.26, SD=0.44; M_{boys}=0.32, SD=0.81, $t(71)=-0.45$, $p>.10$, d=0.09). The use of sensory-focusing was positively correlated with the perceived effectiveness (r=.61, $p<.001$). Perceived effectiveness was not correlated with age (r=.01, $p>.10$), and was similar in boys and girls (M_{girls}=0.55, SD=0.55; M_{boys}=0.79, SD=0.74; $t(69)=-1.53$, $p>.10$, d=0.37). This indicates that regardless of the child's age or sex, the use of sensory-focusing was related with its believed effectiveness.

Impact of pain characteristics

To examine whether characteristics of the pain situation influenced sensory-focusing beliefs, repeated measures analyses were performed. Means and standard deviations are presented in Table 2. Results indicated that pain intensity, novelty and threat did not influence sensory-focusing beliefs (all $F<1$, $p>.10$, $d<0.08$). Results were not influenced by age or sex (all $F<1$, $p>.10$). Independent sample t-tests showed that sensory-focusing (M=0.66, SD=0.65) was believed to be less effective than distraction (M=1.78, SD=1.03) ($t(161)=-11.54$, $p<.001$, d=1.15). Distraction (M=1.82, SD=1.02) is also more often used than sensory-focusing in daily life (M=0.29, SD=0.63) ($t(172)=-16.28$, $p<.001$, d=1.60).

Pain catastrophizing

Catastrophizing was not correlated with the perceived effectiveness of distraction or sensory-focusing (all $r<.14$, $p>.10$). To test whether the effects of pain characteristics on distraction or sensory-focusing beliefs were moderated by the level of catastrophic thinking, a repeated measures analysis was performed. Results showed no interaction-effects of (catastrophizing x pain characteristics) on distraction or sensory-focusing beliefs (all $F<2.4$, $p>.10$).

DISCUSSION

This study showed that children believed distraction to be moderately effective in diminishing pain. In line with study 1, participants believed distraction to be less effective in situations in which pain is perceived as threatening. Distraction beliefs were not influenced by pain novelty. Contrary to study 1, pain intensity did not influence distraction beliefs. Furthermore, results showed that children's beliefs about the effectiveness of sensory-focusing were very low, which is in line with research in adults (Ahles & Blanchard, 1983). Moreover, children do not grasp the meaning of this technique and rarely use this technique in daily life. Sensory-focusing beliefs were not influenced by pain characteristics. Beliefs about sensory-focusing or distraction were independent of the children's age and sex. Finally, catastrophizing did not influence the perceived effectiveness of distraction and sensory-focusing, and did not moderate the influence of pain characteristics on distraction and sensory-focusing beliefs.

GENERAL DISCUSSION

This research examined beliefs about the effectiveness of attentional strategies to cope with pain, and the role of pain characteristics and pain catastrophizing. Research questions were examined in college students (study 1) and schoolchildren (study 2) by means of a vignette approach. In short, results indicated that distraction is believed to be moderately effective (study 1 and 2), and is believed to be more effective than sensory-focusing (study 2). Situational and individual difference variables influenced distraction beliefs (study 1 and 2), but not sensory-focusing beliefs (study 2).

The majority of participants in both studies believed that distraction is moderately effective in reducing pain. This is in line with Leventhal's view of the existence of a common-sense belief about distraction (Leventhal, 1992). Distraction beliefs were however not as strong as was hypothesized, and were situation dependent. For instance, participants in both samples believed that distraction is less effective in situations in which the pain is experienced as threatening. Pain novelty consistently was found not to influence distraction effectiveness beliefs. The role of pain intensity was less clear. Students believed distraction to be less effective in situations characterized by highly intense pain (study 1). In schoolchildren, however, this relationship was not found (study 2). A possible explanation for this discrepancy might lie in the cognitive development of children. Younger children may not easily differentiate between the intensity of the pain and its threatening qualities. Another explanation might be found in the formation of beliefs. Three sources may contribute to the creation of beliefs, namely the general pool of "lay" information (e.g., cultural knowledge), information obtained from significant others (e.g., parents, friends, doctors), and the actual experience, which includes the knowledge about the effectiveness of previous coping attempts (Leventhal, Meyer, & Nerenz, 1980; Leventhal, Nerenz, & Steele, 1984). It is possible that, as intense pain occurs more often in older aged children (Perquin et al., 2000), schoolchildren might have had less experience with highly intense pain than students, and therefore would have had less opportunity to use distraction in intense pain situations and form beliefs about its effectiveness. Despite these differences in schoolchildren and students, it can be concluded that participants had detailed views about the effectiveness of distraction, and that distraction beliefs are not general in nature, but depend upon characteristics of the pain situation.

These findings may have clinical implications. We hypothesized that the existence of a common-sense distraction belief might lead to the persistent use of distraction in situations in which distraction is not effective, and might hinder the use of other pain coping strategies. This now appears unlikely, because distraction beliefs emerged as situation dependent. The finding that distraction is believed to be less effective in threatening and intense pain situations, might prevent people from using distraction in these situations. This is reassuring, because several studies have shown that pain automatically attracts attention in highly intense, threatening and novel pain situations (Crombez et al., 1994; Crombez et al., 1998a; 1998b; Eccleston, 1994; Legrain et al., 2009), providing strong theoretical arguments for distraction being ineffective in these situations (Eccleston & Crombez, 1999). It is therefore of concern that pain novelty did not influence distraction effectiveness beliefs. This might indicate that people also use distraction in novel pain situations. Ignoring pain in novel pain situations may, however, may hold risks of under treatment of the pain.

Results may also have implications for future experimental research. The extent to which beliefs about the effectiveness of distraction may influence distraction studies is unclear. For example, the placebo literature consistently reports the effects of beliefs on analgesia (Benedetti, 2006; Sauro & Greenberg, 2005; Vase, Riley, & Price, 2002), and beliefs may influence the motivation to engage in a distraction task. Checking participants' beliefs about the effectiveness of the attentional coping strategy used, would be a methodological improvement (Eccleston, 1995), as would the routine concealment of the purpose of the experiment.

Distraction was believed to be more effective in reducing pain than sensory-focusing (study 2). Sensory-focusing was not believed to be an effective technique, regardless of the intensity, novelty and threatening nature of the pain situation. These results concur with those of Ahles and colleagues (1983) and show that the effectiveness of sensory-focusing is also counter-intuitive for children. A clinical implication may be that beliefs about the ineffectiveness of sensory-focusing might prevent children from using sensory-focusing in daily life or in pain treatment programs. This is of concern, because sensory-focusing can indeed be effective in diminishing pain in particular contexts (Ahles & Blanchard, 1983; Blitz & Dinnerstein, 1971; McCaul & Haugtvedt, 1982; Piira et al., 2006). However, the present study has shown that the use of sensory-focusing in daily life and the comprehension of this technique are very low. It is possible that children have difficulties understanding the sensory-focusing technique, because it is difficult for them to make a distinction between the sensory and emotional aspects of the pain, which is a fundamental part of the sensory-focusing technique (Goodenough et al., 1999; Piira et al., 2006). Comprehension, however, seems to increase with age. It might therefore be recommended to use the sensory-focusing technique only in older aged children (Piira et al., 2006). Whenever sensory-focusing is used in pain treatment programs, it is important to give thorough information about this technique to strengthen children's beliefs about its effectiveness, in order to increase its use and the adherence to this coping strategy.

Catastrophizing did not influence distraction or sensory-focusing beliefs in schoolchildren (study 2). However, catastrophizing did influence distraction beliefs in students (study 1). Results showed that the more students catastrophized about pain, the more they believed distraction to be less effective for themselves than for others. These results are in line with research findings indicating that distraction is less effective for high catastrophizing individuals (Goubert et al., 2004; Heyneman, Fremouw, Gano, Kirkland, & Heiden, 1990; Verhoeven et al., 2010). The nature of the relationship between catastrophizing, distraction beliefs and distraction effectiveness, however, needs further research. It is possible that high catastrophizing participants learned that distraction is less effective for them, and that they have adjusted their beliefs accordingly. But it is also possible that high and low catastrophizers have different beliefs about the effectiveness of distraction, which in turn causes differences in distraction effectiveness between high and low pain catastrophizers. Anyhow, it can be hypothesized that distraction effectiveness in high catastrophizing individuals might be enhanced by optimizing distraction effectiveness beliefs. Further research is however necessary to investigate this idea and to replicate these preliminary findings.

This study has some limitations. First, participants were generally healthy students (study 1) and schoolchildren (study 2). Generalization of findings to clinical populations is not warranted without further investigation. Second, because the comprehension of the sensory-focusing technique was low (study 2), results of the sensory-focusing vignettes are based on a small sample of participants (*N*=73). Lower statistical power might have prevented the detection of small effects of characteristics of the pain situation on sensory-focusing beliefs. Third, although the total sample of schoolchildren was large (*N*=617), this sample only consisted of 40% of the total school population.

Despite these limitations, this series of studies clearly showed that distraction is believed to be moderately effective to control pain and its effectiveness depends upon situational and individual difference variables. Distraction beliefs are found to be stronger than beliefs about the effectiveness of sensory-focusing.

APPENDICES

Appendix 1: Examples of vignettes used in study 1 (N=263)

Example 1: (low pain intensity/familiar pain/low pain threat).

"The day before an important exam, you experience a mild pain in your stomach. You often have this kind of pain before an exam. You are not worried about the pain. To distract yourself, you think about something pleasant".

Example 2: (high pain intensity/novel pain/high pain threat).

"After a night out, you wake up with a terrible hangover. Your head hurts like hell. You never experienced this kind of pain before. You are worried about the pain. To distract yourself, you talk with someone about something different than the pain".

Appendix 2: Examples of vignettes used in study 2 (N=617)

Example 1: (high pain intensity/familiar pain/high pain treat).

"You went on a fieldtrip with your school. During this trip you had to walk a lot, which caused very intense pain in your leg. You experience pain in your leg a lot. You are worried about the pain".

Example 2: (low pain intensity/novel pain/low pain threat).

"You have eaten too much, which caused a little stomach ache. It is the first time your stomach hurts after eating. You are not worried about the pain".

Appendix 3: Definitions of distraction and sensory-focusing used in study 2 (N=617)

Distraction definition:

Pain frequently occurs in children. When children experience pain, they often try to diminish their pain. For some children it is helpful to divert their attention away from the pain, for instance by :

- *Thinking of other things*
- *Thinking of fun things*
- *Listening to music*
- *Watching TV*
- *…*

*We call this "**distraction**".*

Sensory-focusing definition:

Pain frequently occurs in children. When children experience pain, they often try to diminish their pain. It is sometimes easier to focus attention on the pain than to focuss attention to something else than the pain. For some children it is therefore helpful to focus their attention on the pain and to feel their bodily sensations to decrease their discomfort. They try to describe their pain calmly as if they were a doctor or a researcher themselves, without becoming emotional or overwhelmed by the pain. They focus their attention to:

- *The location of the pain (stomach pain, headache,...)*
- *The type of pain (stabbing/pulsating/pressing,…)*
- *The course of the pain (increase/decrease/no change)*
- *The severity of the pain (intense pain/low pain)*
- *…*

They try to describe the pain and the bodily sensations as good as possible and to feel the pain just like it is, without making an interpretation of the pain ("I have a flue", "I strained my ankle",…) or worry about the pain ("It will probably get worse", "I have to go to a doctor or hospital for sure"…).

*We call this "**sensory-focusing**".*

ACKNOWLEDGMENTS

The authors thank Annabelle Cassier, Elke Van der Cruyssen, Kim Vanderdonck and Caroline Serrure for their help with the data collection, and Tiina Jaaniste for her help with the sensory-focusing definition. They also thank the children from the Bollekensschool, Sint-Barbaracollege, Vrije Basisschool Massemen, Koninklijk Atheneum Mariakerke, Koninklijk Atheneum II and Middenschool van het GO II, and the students from Ghent University for participating in this study.

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CHAPTER 2

THE EFFECTIVENESS OF DISTRACTION EXAMINED IN TWO EXPERIMENTAL PILOT STUDIES USING THE COLD PRESSOR TASK (CPT)[1]

ABSTRACT

Distraction, or directing attention away from pain, is often used to cope with pain and is part of many pain treatment programs. Empirical evidence concerning the effectiveness of distraction is, however, inconclusive. Heterogeneous research findings may partially be the result of methodological weaknesses in research designs. In the current series of studies we investigated the effectiveness of distraction by means of a research design that takes into account many of the methodological problems in previous distraction research. Research questions were examined in two studies. In the first study, 39 undergraduate students participated in a cold pressor experiment. Half of them performed an attention-demanding tone-detection task during immersion of their hand in cold water of 7 °C, the other half did not perform a distraction task during immersion. No effects of distraction were found on attention to pain, pain intensity and pain affect. In the second study (*N*=93), methodological improvements were made and the experiment was repeated with water of 7 °C and 10 °C. Results were similar to the first study, and were independent of the water temperature used. Suggestions for further distraction research are outlined.

[1] Verhoeven, K., Van Damme, S., Van Ryckeghem, D.M.L., & Crombez, G. (submitted). The effectiveness of distraction examined in two studies using the cold pressor task (CPT).

INTRODUCTION

Distraction is an intuitive way of coping with pain, and is part of many pain treatment programs (Morley, Shapiro, & Biggs, 2004). The presumed mechanism underlying its effectiveness is attention (DeMore & Cohen, 2005; Eccleston & Crombez, 1999). When attention is directed away from pain, and subsequently engaged in a distracting task, less pain is experienced (McCaul & Mallot, 1984). Although appealing, empirical evidence supporting the effectiveness of distraction is equivocal (Seminowicz & Davis, 2007; Van Damme, Legrain, Vogt, & Crombez, 2010). Inconclusive research findings may partially be due to methodological differences between studies and weaknesses in research designs (Eccelston, 1995; Piira, Hayes, & Goodenough, 2002).

Several methodological problems in distraction research can be noted (see Eccleston, 1995 for a review). Not only may these problems influence the generalization of study results, but they may also threaten the internal validity of studies. A first problem concerns the induction of pain. Distraction studies have used a variety of pain inducing methods (e.g., heat/cold stimulation, (cold) pressor pain, electrical stimulation, capsaicin cream). However, these methods greatly differ in the pain quality and quantity they provoke (Hastie et al., 2005; Janal, Glusman, Kuhl, & Clark, 1994), making a comparison across studies difficult. Even when the same pain inducing method is used, a comparison across studies may be difficult. For instance, many distraction studies use the cold pressor task (CPT), which requires participants to immerse a hand, foot or limb in cold water for a certain period of time. This provokes a painful stimulation, which is comparable to clinical pain (von Baeyer, Piira, Chambers, Trapanotto, & Zeltzer, 2005). The quality and quantity of the pain largely depends upon the water temperature and immersion duration used (LeBaron, Zeltzer, & Fanurik, 1989; Mitchel, MacDonald, & Brodie, 2004). Research, however, has used very different immersion intervals (e.g., pain tolerance with or without informed ceiling, fixed immersion interval) and water temperatures (e.g., varying from 0 °C to 7 °C and higher), making a comparison across studies difficult. The pain experience can also be influenced by other factors, such as the use of a circulation water pump, the immersion of the wrist, the immersion instructions used, the standardization of the hand temperature before immersion, etc. (von Baeyer et al., 2005). It is often unclear whether these factors are taken into account in previous research. Future research should therefore provide a detailed description of how the CPT is used.

A second problem is related to the assessment of pain. For instance, different pain measurements are used across and within studies (e.g., heart rate, facial pain expression, self/observer-reported pain intensity, pain tolerance, pain treshold). However, these measurements assess different aspects of the pain, and cannot be compared. Also, many factors, such as instructions (Eccleston, 1995), beliefs (Leventhal, 1992), memory bias (Redelmeier, Katz, & Kahneman, 2003) and experimenters' characteristics (Kállai, Barke, & Voss, 2004; Levine & De Simone, 1991) may confound pain reports, and should be accounted for. Further, many researchers ask participants to indicate their experienced pain at different moments during the painful stimulation. This is problematic as people are not able to divert their attention away from the pain while at the same time rating it. This paradoxical instruction might interfere with the distraction process (Eccleston, 1995). Future research should try to avoid interference between the pain measurement and the distraction process. Finally, pain is a complex experience. To improve the reliability and validity of its measurement it is recommended to measure the sensory as well as the affective dimension of the pain, preferably by using multiple items (Fernandez & Turk, 1992; Price, 2000).

A final problem applies to the distraction task used. For instance, many studies use a distraction task without considering an underlying theoretical framework, resulting in a large variety of tasks used (e.g., detection tasks, watching videos, listening to music, smelling odors, viewing pictures). However, the processes underlying their effect may differ (e.g., task difficulty, valence, motivation), making a comparison across studies difficult. Many studies also fail to check whether participants are actually engaged in the distraction task (Eccleston, 1995; Piira et al., 2002). Future research should critically select the distraction task, and check the engagement with the task.

The aim of this research is to investigate the effectiveness of distraction by means of a methodological research design that takes into account many of the methodological pitfalls in the field of distraction. Undergraduate students were randomly assigned to a distraction group, which performed an attention-demanding tone-detection task during the immersion of their hand in cold water, or a control group, which did not perform a distraction task during immersion. We expect participants in the distraction group to report less attention to pain than participants in the control group. Furthermore, we expect distraction to be effective in reducing pain intensity and pain affect.

STUDY 1

METHOD

Participants

Thirty-nine undergraduate students from Ghent University (Belgium) participated in a cold pressor study (27 females, range 17-21 years, M_{age}=18.59 years, *SD*=1.02, all Caucasian). All of them reported to be in good to excellent health, and reported no psychological problems. The minority reported minor medical problems (31%), mostly occasional headaches. Participants were excluded from the sample if they had a history of seizures, cardiovascular diseases, frostbite, cuts, sores or fractures on the hand to be immersed, or Raynaud's disease (von Baeyer et al., 2005). Good comprehension of the Dutch language was also required. Two participants, who reported heart conditions, were excluded from the sample.

All participants performed the experiment to fulfill course requirements and provided written informed consent. They were fully debriefed after the experiment. The research project was approved by the ethical committee of the Faculty of Psychology and Educational Sciences of Ghent University.

Material

Cold pressor task (CPT)

Pain was induced with the cold pressor task (CPT), a safe and reliable method which is often used in pain research (Edens & Gil, 1995; von Baeyer et al., 2005). Participants had to immerse their left hand in a cold water tank. The cold pressor apparatus used, is a commercially manufactured electronic cooler (60 cm x 35 cm x 45 cm), with a round opening in the lid (12 cm x 12 cm) (see Vervoort, Goubert, & Crombez, 2009). A fixed immersion duration of 2 minutes was used to avoid that our self-report measures of pain would be confounded by immersion duration. This way, all participants were exposed to the same physical stimulation. The temperature of the water was maintained at 7 °C (± 0.5 °C) using ice, and a circulating water pump to prevent heating of the water around the immersed hand (von Baeyer et al., 2005). We have chosen a water temperature that most participants were expected to endure for 2 minutes (see Hirsch & Liebert., 1998; Mitchell et al., 2004). We also believed that this particular temperature and immersion duration would elicit pain of moderate intensity, which should be ideal to investigate distraction effects. Lower temperatures often provoke high intense pain, and distraction is argued to be less effective in highly intense pain situations (Eccleston & Crombez, 1999).

To standardize the cold pressor procedure, we used the specific cold pressor guidelines of von Baeyer and colleagues (2005), regarding the exclusion criteria, immersion instructions, hand temperature standardization, and recovery. A bucket with water of 37 °C was used to standardize hand temperature before the cold water immersion and during the recovery afterwards.

Distraction task

The distraction task used was the Random Interval Repetition task (RIR; Vandierendonck, De Vooght, & Van der Goten, 1998a; 1998b). Participants needed to respond as quickly as possible to tones generated by a computer (ASUS L2000) at random inter stimulus interval (tone duration=150 ms; tone pitch=750 Hz; inter stimulus interval of 900 and 1500 ms). Responses were given by means of a button pressing device, held in the right hand. In this study, the total RIR-task duration was 2 minutes, during which 101 tones were presented.

The RIR-task was chosen for several reasons. First, research has shown that this task has the necessary qualities to reduce pain: It demands attention (Vandierendonck et al., 1998a; 1998b), directs attention to an external source (Johnson, Breakwell, Douglas, & Humphries, 1998), and towards another perceptual modality (Villemure & Bushnell, 2002). Second, this task has been used successfully in previous distraction research (Goubert, Crombez, Eccleston, & Devulder, 2004; Van Damme, Crombez, Van Nieuwenborgh-De wever, & Goubert, 2008). Finally, the RIR-task allows an objective measurement of distraction task engagement. Behavioural task performance measures are used as measurements of distraction task engagement (i.e., reaction times (RT), response variation (SD) and errors). RTs faster than 100 ms are considered anticipations and are omitted. Outliers (i.e., RTs > 3 SD above the individual mean) and omissions (i.e., non-responses) are also removed (Goubert et al., 2004; Van Damme et al., 2008). Errors are calculated by summing anticipations and omissions.

All participants performed the RIR-task in the practice phase (no immersion/no pain) and during the hand standardisation phase (immersion/no pain) to obtain baseline measurements of RIR-task performance. During the cold water immersion, the RIR-task was only performed in the distraction group, where it was used as a distraction task (immersion/pain). All participants again performed the RIR-task during the recovery phase (immersion/no pain). Performing the RIR-task several times, would allow more insight in the engagement with this task under different conditions.

Self- report measures

Sample characteristics

Socio-demographic sample characteristics (e.g., sex, age) were assessed with an ad hoc questionnaire, which also included questions about participants' physical and psychological health. Participants indicated their subjective health on a 5-point scale ("bad" to "excellent"). Participants also reported the pain intensity and disability they experienced during the week before testing, how much pain they currently experienced on a numeric rating scale (NRS) (0="no pain/no disability"; 10="very much pain/very disabling"), and the location of the pain (e.g., back, arm, legs).

Self-reported attention to pain

Attention to pain was assessed with two items that measure the same construct but were opposite in formulation to control for response tendency. Participants rated the amount of attention they paid to the pain, and the extent to which they were able to distract themselves from the pain using a 11-point NRS (0="not at all"; 10="very much"). An "attention to pain" score was calculated by subtracting the ability to distract from pain from the amount of attention paid to pain (range -10 to +10). The higher the score, the more attention was paid to the pain during the CPT.

Self-reported RIR-task experience

Participants were instructed to indicate how difficult, interesting and attention demanding the RIR-task was. They also indicated the amount of effort they had put in the task, and how important it was for them to perform the task correctly. All items were scored on a 11-point NRS (0="not at all"; 10="very much"). At the end of the experiment, participants also reflected on the usefulness of the RIR-task as a distraction task. In particular, participants in the distraction group indicated how good the RIR-task actually worked as a distraction task. Participants in the control group were asked to imagine how good the RIR-task could work as a distraction task (0="not at all"; 10="very much").

Self-reported pain experience during the cold pressor test (CPT)

Pain experience was investigated with different self-report items, assessing both pain intensity and pain affect (Price, 2000). To avoid interference between pain report and the distraction process, we assessed the pain experience after the cold pressor task (Eccleston, 1995). Postponed pain ratings may be susceptible to memory bias (Redelmeier et al., 2003), but this can easily be avoided by assessing the pain immediately after the painful experience (Koyama, Koyama, Kroncke, & Coghill, 2004). Pain intensity was assessed with two items. Participants indicated the maximal pain, and the pain they experienced just before the end of the cold water immersion on a NRS from 0 (="no pain") to 10 (="very much pain"). According to Kahneman and colleagues (1993), the end and peak experience are valid indicators of the total pain experience during the CPT. A total pain intensity score was calculated by adding the two pain intensity items (range 0-20). Pain affect was assessed with two items. Participants indicated how unpleasant the CPT experience was, and how tense they were during the cold pressor test on a 11-point NRS (-5="pleasant/relax"; +5="very unpleasant/tense"). A total pain affect score was calculated by adding these pain affect items (range -10 to +10).

Additionally, we asked participants to indicate the pain they experienced after the cold pressor test to measure potential rebound effects of distraction (0="no pain"; 10="very much pain") (Goubert et al., 2004).

Procedure

Participants were randomly (by lottery) assigned to a distraction group, in which attention to pain during the CPT was manipulated using a distraction task, or a control group, in which no distraction task was performed during the CPT.

When entering the experimental room, participants received standard information about the experiment and the cold pressor task, and provided informed consent. They were informed that the main purpose of the experiment was to investigate how *"people react to the cold pressor task"*, which was described as a safe method, which is often used in pain research. Participants were unaware that this experiment was about distraction from cold pressor pain. That way, we minimized the possibility of distraction effects being the result of participants' beliefs in the effectiveness of distraction (Leventhal, 1992). After completing the socio-demographic questions, all participants performed the RIR-task for 2 minutes and completed the RIR-task questions. Next, participants performed the cold pressor procedure, which started with the hand temperature standardization phase (2 minutes), during which all participants performed the RIR-task for the second time. Before the cold water immersion, participants in the control and distraction group received immersion instructions. They were instructed to *"immerse their hand and wrist, not to form a fist and not to move their fingers"* (von Baeyer et al., 2005), and were encouraged to endure the immersion for 2 minutes. Participants in the distraction group simultaneously performed the RIR-task, which served as the distraction task. They were encouraged to "*perform the task well*". Participants in the control group did not perform a task during the cold water immersion. After immersion, the pain experience questions were assessed. The cold pressor procedure ended with the recovery phase, during which all participants performed the RIR-task for the last time. Participants were fully debriefed after the experiment. During the experiment the researcher stayed in the room, but was sitting behind a screen to minimize contact with the participants.

Data analysis

Two participants, both in the distraction group, did not endure the cold water immersion for 2 minutes (M=67.50 sec., SD=26.16), and were removed from the sample. One participant was removed because of an abnormally high number of errors on the distraction task (3 SDs above the group error mean). Statistical analyses (SPSS 15.0) were performed on the remaining 34 participants (distraction group: *N*=17, 10 girls, M_{age}=18.65, *SD*=1.11; control group: *N*=17, 12 girls, M_{age}=18.41, *SD*=0.94).

First, overall RIR-task performance in the distraction and the control group was examined by means of MANOVA repeated measure analysis. We also examined RIR-task experience by means of MANOVA analysis. Multivariate tests are based on Wilk's Lambda. Second, distraction task engagement in the distraction group was examined by means of descriptive analyses. Third, to examine the effects of distraction, ANOVA analyses were performed with attention to pain, pain intensity, pain affect, and pain after the CPT as the dependent variables. Group was entered as between-subjects factor. Cohen's *d* was calculated to determine whether results had a small (0.20), moderate (0.50) or large (0.80) effect size (Cohen, 1988).

RESULTS

Participants' pain characteristics

Descriptive analyses indicated that the majority of the participants (85%) experienced pain during the past week. The pain was mildly intense (*M*=2.86, *SD*=1.71, range 0-10) and provoked little disability (*M*=2.28, *SD*=1.94, range 0-10). Headache (13.8%), backache (10.3%), pain in other parts of the body (e.g., finger, wrist, foot) (20.7%) and multiple pains (48.3%) were most frequently reported. At the moment of testing most participants were pain free (74%); others experienced mild intense pain (*M*=1.22, *SD*=0.44, range 0-10). No difference in current pain experience was found between the distraction group (*M*=0.29, *SD*=0.59) and the control group (*M*=0.35, *SD*=0.61) ($t(32)=-0.29$, $p>.10$, $d=0.10$).

Overall RIR-task performance and experience

RIR-task performance in the distraction and control group was examined by means of MANOVA repeated measure analyses, with time as within-subjects factor, behavioural task performance measures (RT, SD and errors) in the practice, standardization and recovery phase as dependent variables, and group as between-subjects factor. Means and standard deviations of the RIR-task performance measures are presented in Table 1. Multivariate tests showed a main effect of time (F(6,27)=7.77, p<.001). No main effect of group (F(3,30)=0.61, p>.10), nor an interaction-effect of (group x time) was found (F(6,27)=1.04, p>.10). Univariate tests showed that reaction times (F(2,64)=16.73, p<.001) and response variation (F(2,64)=3.17, p<.05) decreased over time. The amount of errors remained invariable over time (F(2,64)=1.65, p>.10).

A MANOVA analysis with self-reported RIR-task experience items (task difficulty, interest, attention to task, effort to perform the task, importance to perform the task) as the dependent variables, and group as between-subjects factor was performed to investigate self-reported RIR-task experience in the distraction and control group. Means and standard deviations are presented in Table 2. Multivariate tests revealed no differences in RIR-task experience between the distraction and control group (F(5,28)=1.06, p>.10). The RIR-task was evaluated as attention-demanding, not difficult, but also not very interesting.

Table 1

Means (M) and standard deviations (SD) of RIR-task performance in the practice, hand standardization, cold pressor and recovery phase in the distraction and control group

Phase		**Distraction (*N*=17) M (SD)**	**Control (*N*=17) M (SD)**
Practice	**RT**	240 (42)	233 (53)
	SD	56 (30)	54 (22)
	Errors	1.06 (2.41)	1.35 (2.06)
Hand standardization	**RT**	217 (31)	220 (51)
	SD	45 (17)	55 (43)
	Errors	0.94 (1.60)	2.65 (3.32)
Cold pressor	**RT**	217 (37)	-
	SD	46 (27)	-
	Errors	2.12 (3.43)	-
Recovery	**RT**	205 (30)	216 (48)
	SD	35 (11)	53 (33)
	Errors	1.35 (1.06)	2.41 (3.78)

Note: The RIR-task was used as a distraction task in the cold pressor phase, the control group did not perform the task during this phase. RT=reaction times; SD=response variation.

Table 2

Means (M) and standard deviations (SD) of RIR-task experience in the distraction and control group

	Distraction (*N*=17) M (SD)	Control (*N*=17) M (SD)
Task difficulty	2.41 (2.29)	2.12 (1.83)
Interest in task	3.06 (2.36)	1.53 (1.12)
Attention to task	7.47 (2.00)	6.88 (1.96)
Importance to perform task	6.24 (1.86)	5.65 (2.69)
Effort to perform task	6.35 (2.26)	5.65 (1.93)
Believed effectiveness of task	4.71 (2.54)	5.71 (2.34)

Distraction task engagement

To check whether participants in the distraction group were engaged in the distraction task, descriptive analyses of behavioural task performance measures (RT, SD, errors) in the cold pressor phase were performed. Results indicated that participants performed the distraction task fast (M=217, SD=37), with little variation in response time (M=46, SD=27), and little errors (M=2.12, SD=3.42) (see Table 1). This indicated that participants were indeed engaged in the distraction task.

Attention to pain

To check whether the experimental manipulation indeed directed attention away from pain, an ANOVA was conducted, with attention to pain as the dependent variable, and group as between-subjects factor. Results showed no differences in attention to pain in participants in the distraction group (M=0.82, SD=4.33, min=-6, max=10) and control group (M=-0.94, SD=4.62, min=-8, max=8) ($F(1,32)$=1.32, p>.10, d=0.39). This indicates that our distraction manipulation was not successful.

Pain experience

To examine the effectiveness of distraction on the pain experience, ANOVA analyses were performed with pain intensity, pain affect, and pain experience after the CPT as dependent variables, and group as between-subjects factor. Results showed no difference in pain intensity between the distraction (M=14.71, SD=3.04, min=8, max=20) and the control group (M=13.12, SD=3.81, min=7, max=20) ($F(1,32)$=1.81, p>.10, d=0.46). This indicates that distraction was not effective in reducing pain intensity.

Furthermore results showed no difference in pain affect between the distraction group (M=5.00, SD=3.18, min=-4, max=9) and the control group (M=3.88, SD=4.01, min=-3, max=10) (F(1,32)=0.81, p>.10, d=0.31). This indicates that distraction was not effective in reducing pain affect. Finally, results indicated that participants in the distraction group reported more pain after the cold pressor test (M=3.88, SD=2.18, min=0, max=7) than participants in the control group (M=2.24, SD=2.33, min=0, max=7) (F(1,32)=4.53, p<.05, d=0.73).

DISCUSSION

In this study, we tried to manipulate attention away from pain during a cold pressor task by means of an attention-demanding tone-detection task, and investigated how this affected the pain experience. Results indicated that we were unable to successfully manipulate attention away from pain. Consequently, no beneficial effects of distraction in terms of a pain reduction were found. Our results even seem to suggest that the cold pressor experience was worse for participants in the distraction group, as they reported significantly more pain after the cold pressor test. This is in line with the study of Goubert and colleagues (2004) who also found paradoxical after-effects of distraction on the pain experience in chronic pain patients. It is, however, premature to conclude that distraction is ineffective in reducing cold pressor pain. Some limitations of the study might explain our results. First, it is possible that the water temperature was too low and the pain experience too high, which could have made it more difficult to direct attention away from pain (Eccleston & Crombez, 1999). Second, the majority of participants in the control group (82%) reported having used spontaneous distraction strategies (e.g., thinking of other things, counting), making it difficult to detect differences in attention to pain between the distraction and control group. Third, participants were cognitively engaged in the RIR-task as a distraction task. However, it has been hypothesized that cognitive engagement in a distraction task might only impact the pain experience, when it is related to a more important goal than the processing of pain (Van Damme et al., 2010). It is possible that performing the RIR-task was not prioritized over the processing of pain. Self-reported RIR-task experience seem to support this hypothesis, as the task was not rated as very interesting, and the effort to perform the task was only moderate. It is possible that the RIR-task is not very interesting in general. However, it is also possible that the participants of this particular study did not find the task interesting. Further research might provide more insight in how the RIR-task is experienced. Finally, it is possible that our pain measurements were not sensitive enough to detect effects.

In light of these shortcomings, a second study was performed in which we further tried to improve the distraction methodology. In particular, it was hypothesized that the ability to distract in study 1 might have been hindered by the pain intensity. In study 2, we therefore used two water temperatures: 7 °C, which would allow a comparison with study 1, and 10 °C. We believed that using a higher water temperature might increase the ability to distract. In order to decrease the use of spontaneous coping strategies, we now explicitly instructed the control group. Participants in the control group were instructed to *“pay attention to the cold pressor task during immersion”*. Finally, we improved our pain measures, by using more extreme poles of the NRS (i.e., “worst imaginable pain” instead of “much pain”), and by assessing pain affect with three items instead of two. We did not change the use of the RIR-task as a distraction task, because we believed in its potential as a distraction task, as previous studies have used this task successfully as a distraction task (Goubert et al., 2004; Van Damme et al., 2008), and study 1 clearly showed that this task is attention-demanding.

STUDY 2

Similar to study 1, we investigated the effectiveness of distraction from cold pressor pain. Participants were randomly assigned to one of four experimental groups: A distraction or control group at 7 °C or 10 °C. We expected distraction to be more effective in diminishing pain intensity and pain affect at 10 °C than at 7 °C.

METHOD

Participants

Ninety-three undergraduate students from Ghent University (Belgium) participated in a cold pressor study (81 females, *Mage*=18.87 years, *SD*=1.10, range 18-24 years, all Caucasian). The same exclusion criteria were used as in the first study (von Baeyer et al., 2005). Based on these exclusion criteria, one participant, who reported a heart condition, was excluded from the sample. Another participant was removed because of poor comprehension of the Dutch language. The majority of the participants reported good to excellent health (88%), and reported no psychological problems (97%). The minority reported minor medical problems (27%), in most cases asthma or allergies.

All participants performed the experiment to fulfill course requirements and provided a written informed consent. They were fully debriefed after the experiment. This research project was approved by the ethical committee of the Faculty of Psychology and Educational Sciences of Ghent University.

Material

Cold pressor task (CPT)

For this study we used a cold pressor apparatus that was more precise at maintaining the water temperature (±0.01) than the one that was used in study 1. The cold pressor apparatus was a metallic water container (Techne B-26 with TE-10D, 530 x 325 x 172 mm) with a circulating water pump (Techne Dip Cooler RU-200). The same fixed immersion duration paradigm was used as in study 1. Half of the participants immersed their left hand for 2 minutes in water of 7 °C, whereas the other half immersed their left hand in water of 10 °C. The guidelines of von Baeyer and colleagues (2005) were again used to standardize the cold pressor procedure. A container (type Julabo TW20, 56 x 35 x 32 cm) with water of 37 °C, was used to standardize the hand temperature before the cold water immersion, and to recover the hand temperature afterwards.

Distraction task

The RIR-task was used as a distraction task (Vandierendonck et al., 1998a; 1998b). The task was used in the same way as in study 1. In this study, however, we tried to reduce possible disturbing environmental influences during the task performance, by presenting the tones through headphones (Sony MDR-V150). Distraction task engagement was examined in the same way as in study 1.

Self-report measures

Socio-demographic characteristics, as well as medical and psychological functioning were assessed with the same items as in study 1. RIR-task experience was assessed with the same items as in study 1. A detailed description of these measurements is provided in the method section of study 1.

Attention to pain was assessed with the same items as in the first study. A total attention to pain score was calculated (range -10 to +10). Pain intensity was assessed with the same items as in study 1. Participants indicated the maximal pain and the pain they experienced just before the end of the cold water immersion (Kahneman et al., 1993). Contrary to study 1, the poles of the NRS used, were formulated more extremely (0="no pain"; 10="the worst imaginable pain"). A total pain intensity score was calculated (range 0-20). Pain affect was now assessed with three items. Participants indicated how unpleasant the CPT was, how tense and also anxious they were (0="very pleasant/not anxious/tense" to 10="very unpleasant/anxious/tense"). A total pain affect score was calculated by adding the three pain affect items (range 0-30). Similar to study 1, participants also indicated the pain they experienced after the CPT to explore possible rebound effects of distraction (0="no pain"; 10="the worst imaginable pain").

Procedure

When entering the experimental room, participants received standard information about the experiment and the CPT (see study 1), and provided informed consent. Participants completed the socio-demographic questions, performed the RIR-task for 2 minutes in the practice phase and completed the RIR-task questions. Next, participants performed the cold pressor procedure, which started with the hand temperature standardization, during which all participants performed the RIR-task for the second time. Before the cold water immersion, participants were given immersion instructions (see study 1) (von Baeyer et al., 2005). Participants in the distraction group performed the RIR-task during the cold water immersion and were instructed to "*concentrate on the task*". Participants in the control group did not perform a task during the cold water immersion, and were instructed "*to pay attention to the cold pressor task*". After immersion the questions about the pain experience were assessed. The cold pressor procedure ended with the recovery phase, during which all participants performed the RIR-task for the last time. Participants were fully debriefed at the end of the experiment. During the experiment the researcher stayed in the room, but was sitting behind a screen to minimize contact with the participants.

Data analysis

Three participants (two in the control group and one in the distraction group), did not endure the cold water immersion for 2 minutes (*M*=38.94 sec., *SD*=18.00), and were therefore removed from the sample. One participant was removed because of an abnormally high number of errors on the distraction task (3 SDs above the group error mean). Statistical analyses (SPSS 15.0) were conducted on the remaining 87 participants (distraction group 7 °C: *N*=24 and 10 °C: *N*=22; control group 7 °C: *N*=20 and 10 °C: *N*=21).

First, overall RIR-task performance was examined by means of MANOVA repeated measure analysis. We also examined RIR-task experience by means of MANOVA analysis. Multivariate test are based on Wilk's Lambda. Second, distraction task engagement was examined with descriptive analysis. Third, to examine effects of distraction, ANOVA were performed with attention to pain, pain intensity, pain affect and pain experienced after the CPT as dependent variables, and group and water temperature as between-subjects variables.

RESULTS

Participants' pain characteristics

Descriptive analyses indicated that the majority of the sample experienced pain during the past week (83%), which was of mild intensity (M=3.10, SD=2.03, range 0-10), provoking little disability (M=3.07, SD=2.21, range 0-10). Headache (14.1%), backache (11.3%), pain in other parts of the body (e.g., neck, throat) (11.3%), and multiple pains (54.9%) were most often reported. At the moment of testing 59% of the participants was pain free, others experienced mild intense pain (M=2.11, SD=1.43, range 0-10). No differences in current pain were found between the four experimental groups ($F(3,82)=0.54$, $p>.10$).

Overall RIR-task performance and experience

RIR-task performance in the four experimental groups was examined by means of MANOVA repeated measure analysis, with time as within-subjects factor, behavioural task performance measures (RT, SD and errors) in the practice, hand standardization and recovery phase as dependent variables, and group and water temperature as between-subjects factors. Means and standard deviations of RIR-task performance are presented in Table 3. Multivariate tests showed no main effects of group and water temperature, nor an interaction-effect of (group x water temperature) (all $F<1.81$, $p>.10$). A main effect of time was found ($F(6,76)=13.72$, $p<.001$), indicating that reaction times and response variation decreased over time (all $F>21$, $p<.001$). The amount of errors also significantly differed over time, without a clear pattern ($F(2,167)=5.20$, $p<.01$). However, the interaction-effect of (time x group) ($F(6,76)=2.94$, $p<.05$), showed that the change in reaction times, response variation and the amount of errors over time differed depending upon the group (all $F>3.8$, $p<.05$).

Self-reported RIR-task experience in the four experimental groups was examined by means of a MANOVA, with self-reported RIR-task experience items (task difficulty, interest, attention to task, effort to perform the task, importance to perform the task) as the dependent variables, and group and water temperature as between-subjects factors. Means and standard deviations are presented in Table 4. Multivariate tests revealed no main effects of group or water temperature, nor an interaction-effect of (group x water temperature) on distraction task experience measures (all $F<1$, $p>.10$).

Table 3

Means (M) and standard deviations (SD) of RIR-task performance in the practice, hand standardization, cold pressor and recovery phase in the distraction and control groups

Phase		Distraction 7°C (*N*=24) M (SD)	Control 7°C (*N*=20) M (SD)	Distraction 10°C (*N*=22) M (SD)	Control 10°C (*N*=21) M (SD)
Practice	**RT**	209 (33)	195 (28)	223 (58)	207 (55)
	SD	66 (37)	59 (27)	65 (27)	63 (36)
	Errors	3.65 (5.25)	4.30 (5.92)	3.14 (4.98)	3.90 (4.93)
Hand standardization	**RT**	189 (23)	181 (29)	203 (45)	220 (87)
	SD	50 (23)	56 (35)	57 (25)	72 (56)
	Errors	2.43 (3.09)	6.45 (6.00)	3.95 (4.43)	6.25 (7.79)
Cold pressor	**RT**	181 (21)	-	209 (59)	-
	SD	47 (27)	-	59 (25)	-
	Errors	6.13 (4.43)	-	7.45 (6.90)	-
Recovery	**RT**	179 (24)	171 (27)	186 (36)	197 (60)
	SD	39 (15)	46 (33)	44 (19)	53 (42)
	Errors	2.78 (2.73)	8.05 (7.19)	4.64 (4.36)	6.00 (7.75)

Note: The RIR-task was used as a distraction task in the cold pressor phase, the control groups did not perform the task during this phase. RT=reaction times; SD=standard deviation.

Distraction task engagement

To check whether participants in the distraction groups were engaged in the distraction task, descriptive analyses were conducted on behavioural task performance measures (RT, SD, errors) in the cold pressor phase (see Table 3). Results indicated that participants in the distraction groups performed the distraction task fast (7 °C: M=181, SD=21; 10 °C: M=209, SD=59), with little variation in response time (7 °C: M=47, SD=27; 10 °C: M=59, SD=25), and little errors (7 °C: M=6.13, SD=4.43; 10 °C: M=7.45, SD=6.90). This indicated that participants in both distraction groups were indeed engaged in the distraction task.

Attention to pain

To check whether the experimental manipulation indeed directed attention away from pain, an ANOVA was conducted, with attention to pain as the dependent variable, and group and water temperature as between-subjects factors. Means and standard deviations are presented in Table 5. Results showed no main effects of group and water temperature, nor an interaction-effect of (group x water temperature) (all *F*<1*, p*>.10) on attention to pain. This shows that participants in the distraction groups, did not reported paying less attention to pain than participants in the control groups, regardless of the water temperature. Our distraction manipulation was not effective at 7 °C or 10 °C.

Table 4

Means (M) and standard deviations (SD) of RIR-task experience in the distraction and control group

	Distraction 7°C (*N*=24) M (SD)	Control 7°C (*N*=20) M (SD)	Distraction 10°C (*N*=22) M (SD)	Control 10°C (*N*=21) M (SD)
Task difficulty	2.08 (2.32)	3.20 (2.65)	2.82 (2.48)	2.86 (2.78)
Interest in task	1.92 (1.89)	2.30 (2.30)	2.05 (1.96)	2.76 (2.39)
Attention to task	7.54 (1.56)	7.65 (1.76)	7.41 (2.13)	8.00 (1.70)
Importance to perform task	6.21 (1.67)	6.25 (2.17)	6.45 (2.22)	6.76 (2.47)
Effort to perform task	6.33 (2.10)	5.70 (2.52)	6.50 (2.20)	7.19 (1.86)
Believed task effectiveness	4.71 (2.58)	6.00 (2.34)	5.45 (2.50)	6.19 (1.69)

Pain experience

To examine the effectiveness of distraction on the pain experience ANOVA were conducted, with pain intensity, pain affect and pain after the CPT as the dependent variables, and group and water temperature as between-subjects factors. Means and standard deviations are presented in Table 5. Results showed no main effects of group and water temperature, nor an interaction-effect of (group x water temperature) on pain intensity (all *F*<1, *p*>.10), and pain affect (all *F*<1.8, *p*>.10). This indicates that pain intensity and pain affect did not significantly differ in the distraction and control groups, regardless of the water temperature. Distraction was ineffective in reducing pain intensity and pain affect at 7 °C and 10 °C. Finally, no main effects of group and water temperature, nor an interaction-effect of (group x water temperature) was found on the pain experience after the CPT (all *F*<1, *p*>.10). Participants in the distraction and control groups did not differ in the amount of pain experienced after the CPT, regardless of the water temperature. Contrary to study 1, no evidence was found for rebound-effects.

Table 5

Means (M), standard deviations (SD), minima and maxima of attention to pain, pain intensity, pain affect, and pain after the CPT in the distraction and control groups

	Distraction 7°C (*N*=24)			**Control 7°C (*N*=20)**			**Distraction 10°C (*N*=22)**			**Control 10°C (*N*=21)**		
	M (SD)	**min**	**max**	**M (SD)**	**min**	**max**	**M (SD)**	**min**	**max**	**M (SD)**	**min**	**max**
Attention to pain	0.83 (3.67)	-7	7	0.55 (3.94)	-7	10	0.14 (3.76)	-5	8	0.67 (4.13)	-9	8
Pain intensity	12.79 (3.06)	7	18	13.25 (2.95)	6	18	13.00 (3.44)	6	17	12.95 (4.35)	3	19
Pain affect	17.29 (4.44)	9	25	16.95 (6.49)	7	28	18.09 (5.25)	9	27	19.10 (4.61)	9	29
Pain after the CPT	4.25 (2.19)	1	8	3.65 (2.50)	0	9	3.73 (2.55)	0	9	3.76 (2.43)	0	7

DISCUSSION

We investigated the effectiveness of distraction in reducing cold pressor pain, using water temperatures of 7 °C and 10 °C. At 7 °C, we were unable to manipulate attention away from the pain. Distraction was also ineffective in reducing pain intensity and pain affect. These results hereby replicate the results of study 1. We did, however, expect to find effects of distraction at 10 °C, as we anticipated less intense pain when using this water temperature, which should make it more easy to distract attention away from pain. However, the pain experience at 10 °C was similar to the pain experience at 7 °C. At 10 °C we were also unable to divert attention away from pain, and distraction was not effective in reducing pain intensity and pain affect.

GENERAL DISCUSSION

This research aimed at investigating the effectiveness of distraction in reducing cold pressor pain, by using a research design that takes into account many of the methodological problems of earlier distraction research. A distraction paradigm was used in which participants immersed their hand in cold water of 7 °C and 10 °C. Half of them simultaneously performed an attention-demanding tone-detection task (distraction group), the other half did not (control group). Results can be readily summarized. At 7 °C as well as at 10 °C, we were unable to divert attention away from the pain in the distraction groups. Moreover, no differences in pain intensity and pain affect occurred between the distraction and control groups.

Many studies have investigated the effectiveness of distraction, with varying success (e.g., Cioffi & Holloway, 1993; Goubert et al., 2004; James & Hardardottir, 2002; Johnson, et al., 1998; Marchand & Arsenault, 2002; McCaul & Haugtvedt, 1982; McCaul, Monson, & Maki, 1992; Van Damme et al., 2008). Our research, however, has further value over previous research, as we tried to avoid many methodological pitfalls in distraction research (Eccleston, 1995). Nevertheless, we were unable to successfully divert attention away from the pain. Several explanations can account for these results.

It has been argued that directing attention away from pain might be hindered by bottom-up characteristics of the pain (Eccleston & Crombez, 1999; Legrain et al., 2009).

For instance, there are strong theoretical arguments for distraction being less effective in situations of intense pain (Eccleston & Crombez, 1999). Therefore we used relatively high water temperatures in comparison with other distraction studies (e.g., Cioffi & Holloway, 1993; Johnson & Petrie, 1997; Roelofs, Peters, van der Zijden, & Vlaeyen, 2004). However, at 7 °C the overall pain intensity was relatively high (study 1: M=13.91, SD=3.48, range 7-20; study 2: M=13.00, SD=2.99, range 6-18). Because research has shown that significant differences in pain intensity can be found with a minimal difference of 2 °C (Mitchell et al., 2004), we also investigated the effectiveness of distraction at 10 °C (von Baeyer et al., 2005). Results, however, showed no differences in the pain experience at 7 °C and 10 °C. At 10 °C the pain intensity was still relatively high (M=12.98, SD=3.86, range 3-19), which might have made it difficult to direct attention away from pain. Other bottom-up characteristics of the pain, such as pain novelty, may also have hindered the effectiveness of distraction. However, this explanation is less likely for explaining our results. It is reasonable to assume that pain novelty mainly hinders distraction in the beginning of the painful stimulation. The immersion lasted for 2 minutes, which should be long enough to overcome the novelty of the pain, and become engaged in the distraction task. Additionally, by asking about the maximal pain and the pain experienced just before the end, we decreased the possibility of our pain intensity measurement being confounded by the novelty of the pain.

Further, the use of spontaneous distraction strategies in our control groups might have hindered the detection of distraction effects. In study 1, 82% reported having used spontaneous distraction strategies. In study 2, we tried decreasing the use of spontaneous distraction strategies by instructing the control group to pay attention to the CPT during immersion. Nevertheless, 66% of all control participants reported to have used spontaneous distraction strategies (respectively 7 °C: 60%; 10 °C: 71%), and the perceived effectiveness of these strategies did not differ from the perceived effectiveness of the experimental distraction task (7 °C: $M_{distrac}$=6.13, SD=1.86, M_{contr}=6.00, SD=2.49; 10 °C: M_{distr}=6.93, SD=1.44, M_{contr}=6.20, SD=2.21, all F<1, p>.10). Future studies may find ways to further decrease the use of spontaneous distraction in the control groups.

Finally, the distraction task used had the necessary qualities to be effective in reducing pain. It was attention-demanding (Vandierendonck et al., 1998a; 1998b), directed attention to an external cue (Johnson et al., 1998), involved another perceptual modality (Villemure & Bushnell, 2002), and has been successfully used in previous distraction research (Goubert et al., 2004; Van Damme et al., 2008). However, results of the current studies indicated some problems with the use of the RIR-task as a distraction task. The RIR-task was attention-demanding, but across studies, the task was not rated as very interesting and the effort to perform the task well was also moderate. It is possible that the task did not gain priority over the processing of pain, and therefore did not impacted the pain experience (Van Damme et al., 2010). In order to increase the effectiveness of the RIR-as a distraction task, future research should try to increase participants' motivation to perform the task. That way, the possibility of this task becoming prioritized over the processing of pain might increase. The motivation to perform the task may for instance be increased by performing this task only once, by shortening the duration of the task, by using feedback of the task performance, or by using incentives (Bonner & Sprinkle, 2002).

We additionally explored rebound-effects of distraction. Across studies we did not consistently find rebound-effects of distraction. This indicates that distraction does not always produce rebound-effects. It is possible that rebound-effects only appear when large effort is needed to divert attention away from pain. For instance, when the pain is very intense, or threatening, or when the distraction task is very difficult. It might be more interesting to investigate influencing factors of rebound-effects of distraction, for instance by manipulating these factors, instead of simply documenting rebound-effects.

Several points of interest may be formulated for the methodological improvement of future distraction research:

1) Investigating distraction effectiveness is much more complicated than it first appears. Several characteristics of the pain (e.g., pain intensity, pain novelty, pain threat) may hinder the effectiveness of distraction (Eccleston & Crombez, 1999). In order to increase the possibility of finding a standard distraction effect, it might therefore be recommended to use a stimulus of moderate pain intensity. The impact of the novelty of the pain might be decreased by familiarizing participants with the painful procedure beforehand, or by using pain measurements that are less sensitive to the effects of pain novelty.

2) When using the CPT as a pain induction method, it is important to keep in mind that the pain experience is not only determined by the water temperature, other factors should also be taken into account (e.g., the immersion interval, immersion instructions, the use of a circulation water pump, the use of a hand standardization phase before the immersion in cold water, etc.). In light of the hypothesis under test, it is therefore important to pilot the CPT and its parameters to gain more insight in the pain quality and quantity provoked. It is also important to provide a detailed descriptions of how the CPT is used.
3) Future distraction research should carefully think about the control group used. Depending upon the hypothesis under test, the use of spontaneous coping strategies in the control group might be a problem. The use of such strategies might to some point be decreased by using instructions in the control group.
4) In future research, distraction tasks should be used that are based on a theoretical framework. It is also very important to check and report the engagement with this task. The RIR-task can be used as a distraction task, but its effectiveness might be increased by increasing the motivation to perform the task.
5) Future research should pay attention to the pain measurements used. Both pain intensity and affect should be assessed, preferably by using different items. Pain is best measured after the pain inducing procedure to avoid interference with the distraction process. Confounding influences of pain report should be minimized. For instance, memory bias can be decreased by assessing the pain immediately after the painful procedure (Koyama et al., 2004). Experimenters' effects can be minimized by minimizing the contact with the participants during the experiment.
6) In order to decrease the possibility of distraction effects being the result of participants' beliefs in the effectiveness of distraction (Leventhal, 1992), the true purpose of the experiment could be concealed. In all other cases, participants' beliefs should be assessed and controlled for.

In conclusion, this research has shown that distraction is not always effective and investigating distraction effectiveness is more complicated than it first appears. Many methodological pitfalls should be taken into account in order to study distraction effectiveness in a more systematic way. Inspiration may be found in the current series of studies.

ACKNOWLEDGMENTS

The authors thank Lieselote Vermeulen, Barbara Mahieu and Christof Piron for their help with the data collection, and Pascal Mestdagh for the technical support. Preparation of this paper was partly supported by Grant BOF/GOA2006/001 of Ghent University.

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CHAPTER 3

THE ROLE OF MOTIVATION AND PAIN CATASTROPHIZING IN DIRECTING ATTENTION AWAY FROM PAIN: AN EXPERIMENTAL STUDY[1]

ABSTRACT

Research on the effectiveness of distraction as a method of pain control is inconclusive. One mechanism pertains to the motivational relevance of distraction tasks. In this study the motivation to engage in a distraction task during pain was experimentally manipulated. Undergraduate students (*N*=73) participated in a cold pressor task (CPT), and were randomly assigned to three groups: A distraction-only group performed a tone-detection task during the CPT, a motivated-distraction group performed the same task and received a monetary reward for good task performance, and a control group did not perform the tone-detection task. Results indicated that engagement in the distraction task was better in the motivated-distraction group in comparison with the distraction-only group. Participants in both distraction groups experienced less pain compared to the control group. There were no overall differences in pain intensity between the two distraction groups. The effect of distraction was influenced by the level of catastrophic thinking about pain. For low catastrophizers, both

[1] Verhoeven, K., Crombez, G., Eccleston, C., Van Ryckeghem, D.M.L., Morley, S., & Van Damme, S. (2010). The role of motivation in distracting attention away from pain: An experimental study. *Pain, 149*, 229-234.

distraction groups reported less pain as compared to the non-distracted control group. This was not the case for high catastrophizers. For high catastrophizers it mattered whether the distraction task was motivationally relevant: High catastrophizers reported less intense pain in the motivated distraction group, as compared to the non-distracted control group. We conclude that increasing the motivational relevance of the distraction task may increase the effects of distraction, especially for those who catastrophize about pain.

INTRODUCTION

Distraction is an intuitive way of coping with pain, and is part of many pain treatment programs (Morley, Shapiro, & Biggs, 2004). The putative mechanism for its perceived effectiveness is attention: When attention is directed away from pain, less attention is available for pain, and less pain is experienced (McCaul & Malott, 1984). Although appealing, empirical evidence in support of this view is inconclusive (Eccleston, 1995; Seminowicz & Davis, 2007a). Pain characteristics as well as distraction task characteristics may account for the disparities in empirical findings (Eccleston & Crombez, 1999).

Until now, research has mainly focused on the effects of pain characteristics. Behavioural as well as neuropsychological studies have revealed that the capture of attention by pain is enhanced when pain is intense, novel, and threatening (Crombez, Baeyens, & Eelen, 1994; Crombez, Eccleston, Baeyens, & Eelen, 1997; 1998a; Eccleston, 1994; Legrain et al., 2009). It may well be that distraction is less effective in these situations (Eccleston & Crombez, 1999). Largely unexplored is the influence of distraction task characteristics. This research has been predicated on the general capacity or resource models of attention which state that there is a limited amount of cognitive resources that has to be divided between multiple demands (Broadbent, 1958; Kahneman, 1973). According to these models distraction tasks must demand more cognitive resources than pain in order to be effective. Studies investigating this idea have manipulated the difficulty of the distraction task. However, results do not support the central role of task difficulty (Hodes, Howland, Lightfoot, & Cleeland, 1990; McCaul, Monson, & Maki, 1992; Seminowicz & Davis, 2007b), thereby challenging the validity of the capacity models.

It is possible that one’s attentional engagement in a distraction task depends upon the affective-motivational characteristics of the task rather than its cognitive difficulty (Eccleston & Crombez, 1999; Leventhal, 1992). Motivational models of attention may then be more appropriate to understand distraction (Norman & Shallice, 1986). According to these models the allocation of attention is determined by the activation of goals in working memory (Legrain et al., 2009). Goal-relevant information is given priority to enter in working memory, and goal-irrelevant information is inhibited

(Fishbach & Ferguson, 2007; Goschke & Dreisbach, 2008; Shah, Friedman, & Kruglanski, 2002). Motivationally relevant distraction tasks might therefore be more effective in diminishing pain (Van Damme, Legrain, Vogt, & Crombez, 2010), because they are more likely to get priority processing over pain. This hypothesis has not yet been tested.

Whether distraction works to reduce pain may also depend upon individual differences in catastrophic thinking about pain, which is defined as an exaggerated negative orientation towards actual or anticipated pain experiences (Sullivan, Bishop, & Pivik, 1995). Those who catastrophize about pain, experience pain as threatening, are hypervigilant to pain (Crombez, Van Damme, & Eccleston, 2005) and have difficulties disengaging attention from pain (Van Damme, Crombez, & Eccleston, 2004; Van Damme, Crombez, & Lorenz, 2007). It is therefore reasonable to assume that pain processing is prioritized over the processing of other information, making it more difficult to engage in a distraction task, and as a consequence making distraction less effective (Goubert, Crombez, Eccleston, & Devulder, 2004; Heyneman, Fremouw, Gano, Kirkland, & Heiden, 1990).

This study investigated whether the motivational relevance of the distraction task can enhance the effectiveness of distraction from laboratory controlled cold pressor pain. We hypothesized that participants would experience less pain when attention was directed away from pain. Further, we hypothesized that the effects of distraction would increase when participants are financially rewarded for good task performance. Finally, we hypothesized that distraction would be less effective for participants who catastrophize about pain.

METHOD

Participants

Seventy-eight undergraduate students (66 females, mean age=18.67 years, *SD*=1.36) from Ghent University (Belgium) participated in a cold pressor experiment. Data were collected in November 2007. All participants were Caucasian. The majority of the participants reported good medical and psychological health. Participants were excluded if they had a history of epilepsy, cardiovascular diseases, and cuts or sores on the hand to be immersed (von Baeyer, Piira, Chambers, Trapanotto, & Zeltzer, 2005).

Good comprehension of the Dutch language was also required. Three participants were excluded: One did not fully understand Dutch, one had had a recent hand surgery, and one reported epilepsy. Furthermore, two participants were removed from the sample because of a large number of errors on the distraction task (> 3 SDs above the mean). Statistical analyses were conducted on a final sample of 73 participants (61 females, mean age=18.73 years, *SD*=1.38). All participants participated to fulfill course requirements and provided a written informed consent. Participants were fully debriefed after the experiment. The experiment was approved by the ethical committee of the Faculty of Psychology and Educational Sciences of Ghent University.

Material

Cold pressor task (*CPT)*

The cold pressor apparatus used was a metallic water container (Techne B-26 with TE-10D, 530 x 325 x 172 mm). The water temperature was kept at 12 °C (± 0.01) using a circulating water pump (Techne Dip Cooler RU-200). We used a fixed immersion duration paradigm, in which participants had to immerse their hand in cold water for a fixed period of time. As a consequence our self-reported measure of pain is not confounded by tolerance time (Eccleston, 1995). With this particular paradigm it is necessary that a sufficient number of participants endure the painful stimulation until the end.

Temperature and immersion interval were chosen based upon theoretical considerations and pilot studies. Previous distraction studies have used very low water temperatures (0-5 °C), resulting in a relatively high dropout (e.g., Jackson et al., 2005). Therefore we performed several pilot studies with a fixed immersion paradigm with higher water temperatures. We started piloting at 7 °C, as research indicated that participants should be able to endure water of 7-8 °C for 1 to 2 minutes (Hirsh & Liebert, 1998; Mitchell, MacDonald, & Brodie, 2004). Pilot studies however revealed that with temperatures of 7 °C and even 10 °C, and an immersion interval of two minutes, pain ratings were relatively high with less variation, and a relatively high number of participants was unable to tolerate the cold pressor pain for two minutes. Since distraction is thought not to work when pain is intense (Eccleston & Crombez, 1999), we have chosen a water temperature of 12 °C and an immersion duration of one minute. We expected that this would create a painful stimulus of average pain intensity, which would be ideal to measure distraction effects, and could be endured by most participants.

Another container (type Julabo TW20, 56 x 35 x 32 cm), filled with room temperature water (21 °C), was used to standardize hand temperature before immersion of the hand in the cold water container (von Baeyer et al., 2005).

Distraction task

The distraction task used was the Random Interval Repetition task (RIR; Vandierendonck, De Vooght, & Van der Goten, 1998). This task has been successfully used in previous distraction research (Goubert et al., 2004; Van Damme, Crombez, Van Nieuwenborgh-De wever, & Goubert, 2008). The RIR-task is an attention-demanding tone-detection task, which requires executive processing. Participants are required to respond as quickly as possible to tones (tone duration=150 ms; tone pitch=750 Hz; inter stimulus interval 900 and 1500 ms) generated by a computer (ASUS L2000). Tones were presented at random stimulus interval through headphones (Sony MDR-V150). In this study, the total RIR-task duration was 1 minute during which 51 tones were presented. Responses were made by pressing a button pressing device, held in the right hand. Task performance was assessed by reaction times (RT), response variation (SD) and errors. RTs faster than 100 ms were considered anticipations and omitted. Outliers (RTs > 3 SD above the individual mean) and omissions were also removed (Goubert et al., 2004; Van Damme et al., 2008). Errors were calculated by summing anticipations and omissions. Task performance served as a behavioural measure for task engagement.

Self-report measures

Sample characteristics

Socio-demographic sample characteristics (e.g., sex, age) were assessed with an ad hoc questionnaire, which also included questions about participants' physical and psychological health.

Pain experience prior to the experiment was assessed with the Graded Chronic Pain Scale (Von Korff, Ormel, Keefe, & Dworkin, 1992). Research indicated that this questionnaire is valid and reliable for several pain problems (Von Korff et al., 1992). This questionnaire contains several numeric rating scales (NRS) (0-10) that measure pain intensity (three items, namely pain right now, worst pain and average pain during 6 months) and disability (three items, namely interference with daily activities, social activities and work activities). Total intensity and disability scores vary from 0-100. Participants also register the total number of disability days during the past 6 months (range 0-180). Participants are classified in grades 0 (“pain free”) to 4 (“high disability-severely limiting”).

Pain catastrophizing

Catastrophic thinking about pain was assessed with the Dutch version of the Pain Catastrophizing Scale (PCS; Crombez et al., 1998b; Sullivan et al., 1995). This scale contains 13 items that measure catastrophic thoughts about pain in both clinical and non-clinical samples. Participants reflect on past painful experiences and indicate on a 5-point scale ranging from 0 (“not at all”) to 4 (“always”) the degree to which they experience each of the 13 thoughts or feelings during pain (i.e., “I become afraid that the pain may get worse”). Research has shown that the Dutch version of the PCS is valid and reliable (Van Damme, Crombez, Bijttebier, Goubert, & Van Houdenhove, 2002). In the present study Cronbach’s alpha of the total score was .85.

Self-reported attention to pain

Attention to pain was assessed with two items that measure the same construct but were opposite in formulation to control for response tendency. Participants rated the amount of attention they paid to the pain, and the extent to which they were able to distract themselves from the pain using a 11-point NRS (0=“not at all”; 10=“very much”). An “attention to pain” score (range -10 to +10) was calculated by subtracting the ability to distract from pain from the amount of attention to pain. The higher the score, the more attention paid to pain during the CPT.

Self-reported distraction task experience

Distraction task experience and motivation to perform the task were assessed with six items. Participants were instructed to indicate the difficulty of the task, their interest in the task, and the amount of attention paid to the task on a 11-point NRS (0="not at all"; 10="very much"). They were also instructed to indicate the amount of effort that they put in the task, and how important it was for them to perform the task correctly. Finally, participants' beliefs about the effectiveness of the distraction task were assessed.

Self-reported pain experience during the cold pressor test (*CPT)*

Participants reported their experienced pain. A distinction was made between pain intensity and pain affect (Eccleston, 1995; Leventhal, 1992). Pain intensity was assessed with two items (Cronbach's alpha=.92). Participants indicated the "worst pain" and the "pain just before the end of the immersion" on a 11-point NRS (0="no pain"; 10="the worst imaginable pain"). According to Kahneman and colleagues (1993) these two measures are valid indicators of the pain experience during the CPT. A total pain intensity score was computed (range 0-20).

Pain affect was assessed with three items (Cronbach's alpha=.64). Participants indicated how unpleasant the experience was, and how anxious and tense they were during immersion on a 11-point NRS (0="not anxious/relaxed/pleasant"; 10="very anxious/tense/unpleasant"). A total pain affect score was computed (range 0-30).

Experimental manipulation

Participants were randomly assigned (by lottery) to one of three experimental groups: (1) A distraction-only group (*N*=24), (2) a motivated-distraction group (*N*=23), and (3) a control group (*N*=26). In the two distraction groups the same distraction task was performed. In the motivated-distraction group, participants were rewarded for their task performance. We chose a feasible goal with a high goal value to create motivation (Förster, Liberman & Higgins, 2005). Participants could win 10 eurocents every time they pressed the button quickly and accurately. If the response was given too late or inaccurately, they could lose 10 eurocents. Participants could earn a maximum of 6 euro. During the task no performance feedback was given. After the experiment, participants received 3, 4 or 5 euro for their task performance. This amount was randomly assigned and was unrelated to their actual performance.

Procedure

Participants received standard information about the experiment when entering the experimenters' room. They were instructed to *"perform several cognitive tasks and a cold pressor taskt (CPT)"*. Furthermore, they were informed that *"the main interest of the experiment was to examine the effect of an aversive experience on cognitive functioning"*. The real purpose of the experiment was masked, and participants were unaware that the experiment was about distraction from cold pressor pain. That way, potential placebo effects were kept at a minimum. After instructions, the PCS was assessed, and participants performed the cognitive tasks, which were of no relevance for this study (task completion took approximately 30 minutes).

Next, participants received standard information about the cold pressor procedure. First, they had to immerse their left hand for 1 minute in the room temperature tank to standardize hand temperature (von Baeyer et al., 2005). Before the cold water immersion, participants in the two distraction groups received information about the distraction task. Both groups were instructed to *"focus on the task during immersion".* Participants in the motivated-distraction group were also informed of the importance to perform the task well. They were instructed that *"they could earn 10 eurocent every time they pressed the button fast and accurately and lose 10 eurocent every time they pressed the button too late or inaccurately, with the possibility to earn a maximum of 6 euro, which they would receive at the end of the experiment"*. Participants in the control group were instructed to *"keep their thoughts on the cold water and the pain they experienced"* (Leventhal, Brown, Shacham, & Engquist, 1979). Participants were also instructed to *"immerse their hand and wrist, not to form a fist and not to move their fingers"* (von Baeyer et al., 2005). After instructions, participants immersed their left hand in the cold water container for 1 minute. Immediately following the immersion, they answered questions about the experienced pain (Koyama, Koyama, Kroncke, & Coghill, 2004). The distraction task questions were only assessed in the two distraction groups. The cold pressor procedure ended with a submersion for 1 minute in the room temperature tank for recovery (von Baeyer et al., 2005). Participants were debriefed at the end of the experiment. During the experiment the researcher stayed in the room, and sat behind a screen to minimize the contact with the participant.

Data analysis

For data analysis SPSS 15.0 was used. First, the engagement of the participants in the distraction task was examined. Second, ANCOVA analyses were conducted to examine any effects of distraction on attention to pain, pain intensity, and pain affect. Catastrophizing was entered as a covariate in all analyses. As recommended by Van Breukelen and colleagues (2007), this variable was centred. Significant main effects were further evaluated using contrast analyses. We compared the control group with the two distraction groups to evaluate the global effect of distraction. Furthermore we compared the control group with the two distraction groups separately to gain more insight in the distraction effects, and finally we compared the two distraction groups to see whether motivated-distraction has beneficial effects over distraction without extra motivation. A priori hypotheses were tested with one-tailed *t*-tests. Effect sizes were calculated by using Cohen's *d* (0.20 'small', 0.50 'medium' or 0.80 'large' effects), or partial eta squared (ηp^2) (.01 'small', .10 'medium' and .25 'large' effects) (Cohen, 1988).

RESULTS

Sample characteristics

The majority of the participants (89%) had experienced some pain during the past 6 months (e.g., headache, stomach ache, back pain). Ninety percent was defined as non-persistent pain that was of average intensity (M=45.38, SD=18.05; range 13-80) and mildly disabling (M=31.70, SD=24.84; range 0-97). The majority of the participants (82%) was classified in grade 0 ("no pain problem"), 1 ("low disability-low intensity") or 2 ("low disability-high intensity"). Pain grades were equally distributed between experimental groups ($\chi^2(8)=8.06$, $p>.05$).

Manipulation checks

To investigate distraction task engagement in both distraction groups, ANCOVA analyses were conducted with behavioral task performance measures (reaction times, response variation and errors) as dependent variables, group as between subjects factor, and catastrophizing as covariate (see Table 1). In comparison with the distraction-only group, the motivated-distraction group, performed the distraction task significantly faster ($F(1,43)=4.63$, $p<.05$, $d=0.65$) without being less accurate ($F(1,42)=1.73$, $p>.05$, $d=0.39$). Participants in the motivated-distraction group also showed less variability in response speed ($F(1,43)=4.90$, $p<.05$, $d=0.66$). There were no main effects of catastrophizing or interaction-effects of (catastrophizing x group) on behavioral task performance measures (all $F<1.5$).

Furthermore, a MANCOVA analysis was conducted with self-reported distraction task experience measures (attention to the task, task difficulty, interest in the task, effort to perform the task, importance to perform the task, and beliefs about the effectiveness of the task) as dependent variables, group as between-subjects factor, and catastrophizing as covariate (see Table 1). The multivariate test revealed a significant main effect of group on self-reported distraction task engagement ($F(6,37)=2.42$, $p<.05$, $\eta p^2=.28$). Univariate tests were used to further examine the effects of the self-reported task engagement items separately. Results indicated that both groups reported an equal amount of attention paid to the distraction task ($F<1$). In comparison with the distraction-only group, the motivated-distraction group experienced the distraction task as more interesting ($F(1,42)=4.24$, $p<.05$, $d=0.58$). They also expended more effort performing the task well ($F(1,42)=9.40$, $p<.01$, $d=0.87$). Multivariate tests showed no main effects of catastrophizing, nor interaction-effects of (catastrophizing x group) on self-reported distraction task engagement (all $F<1.3$).

The results of behavioral as well as self-report measures clearly showed that the motivated-distraction group was more engaged in the distraction task than the distraction-only group, and that our manipulation of motivation was indeed successful.

Table 1

Means (M) and standard deviations (SD) of behavioral and self-reported distraction task (RIR) engagement measures

	Distraction-only (*N*=24) M (SD)	**Motivated-distraction (*N*=23) M (SD)**
Reaction times RIR	259.98 (59.57)	224.77 (48.03)
Response variation RIR	78.33 (40.25)	56.46 (23.63)
Errors RIR	2.13 (2.11)	1.41 (1.53)
Attention to RIR	8.13 (1.42)	8.43 (1.31)
Task difficulty	2.78 (2.13)	2.22 (1.76)
Interest in RIR	3.96 (2.48)	5.39 (2.46)
Importance to perform RIR	6.96 (1.74)	7.30 (1.69)
Effort to perform RIR	5.87 (2.51)	7.74 (1.68)
Believed effectiveness RIR	6.87 (2.18)	7.00 (2.11)

Note: RIR=Random Interval Repetition task.

Means and standard deviations of self-reported attention to pain are presented in Table 2. An ANCOVA analysis was conducted with attention to pain as dependent variable, group as between-subjects factor, and catastrophizing as covariate. Means and standard deviations of self-reported attention to pain are presented in Table 2. Results revealed a main effect of group on self-reported attention to pain ($F(2,67)=23.43$, $p<.01$, $\eta p^2=.41$). Contrast analyses were performed to further evaluate significant main effects and test a priori hypotheses. Results showed a significant difference in attention to pain between the control group and both distraction groups ($t(70)=6.44$, $p<.01$, $d=1.54$). The distraction-only group ($t(70)=4.60$, $p<.01$, $d=1.25$) as well as the motivated-distraction group ($t(70)=6.45$, $p<.01$, $d=2.07$) reported significantly less attention to pain compared to the control group. The motivated-distraction group reported significantly less attention to pain than the distraction-only group ($t(70)=1.87$, $p<.05$, $d=0.52$).

Furthermore, there was a main effect of catastrophizing on attention to pain ($F(1,67)=6.58$, $p<.05$, $\eta p^2=.09$), indicating that higher levels of catastrophizing were associated with more attention to pain. There was no interaction-effect of (catastrophizing x group) on attention to pain ($F<1$).

Table 2

Means (M) and standard deviations (SD) of self-reported attention to pain and pain experience during the CPT

	Control (N=26) M (SD)	Distraction-only (N=24) M (SD)	Motivated- distraction (N=23) M (SD)
Attention to pain	3.08 (2.83)	-1.08 (3.80)	-2.83 (2.89)
Pain intensity	11.00 (3.63)	8.83 (4.62)	8.48 (3.94)
Pain affect	15.81 (5.48)	14.58 (5.53)	14.17 (3.68)

Self-reported pain intensity

Means and standard deviations of self-reported pain experience are shown in Table 2. An ANCOVA with pain intensity as dependent variable, group as between-subjects factor and catastrophizing as covariate revealed a significant main effect of group on pain intensity ($F(2,67)= 3.21$, $p<.05$, $\eta p^2=.09$). Contrast analyses were performed to further evaluate significant main effects and test a priori hypotheses. A significant difference in reported pain intensity was found between the control group and the two distraction groups ($t(70)=2.35$, $p<.05$, $d=0.57$). The distraction-only group ($t(70)=1.88$, $p<.05$, $d=0.52$), as well as the motivated-distraction group ($t(70)=2.16$, $p<.05$, $d=0.67$), reported less pain intensity compared to the control group. There was no significant difference in reported pain intensity between the two distraction groups ($t(70)=0.30$, $p>.05$, $d=0.08$).

Furthermore, there was a significant main effect of catastrophizing on pain intensity ($F(1,67)=6.37$, $p<.05$, $\eta p^2=.09$), indicating that higher levels of catastrophizing were associated with more pain. Finally, the interaction-effect of (catastrophizing x group) on pain intensity approached the significance cut off of 5% ($F(2,67)=2.92$, $p=.06$, $\eta p^2=.08$). To visualize this trend, we divided the sample into high ($N=39$, $M=23.46$, $SD=5.09$, range 17-36) and low catastrophizers ($N=34$, $M=10.78$, $SD=3.87$, range 3-16) using PCS norm scores calculated in a large sample of Dutch-speaking undergraduate students ($N=550$) (Van Damme et al., 2002). Group means are presented in Figure 1. Contrast analyses were performed to test differences between groups in reported pain intensity separately for high and low catastrophizers. For low catastrophizers, both distraction groups reported significantly less pain as compared to the non-distracted control group ($t(31)=1.98$, $p<.05$, $d=0.71$). This was not the case for high catastrophizers

($t(36)=1.55$, $p>.05$, $d=0.49$). However, for high catastrophizers it mattered whether the distraction task was motivationally relevant: High catastrophizers reported less intense pain in the motivated distraction group, as compared to the non-distracted control group ($t(36)=1.81$, $p<.05$, $d=0.79$), but there was no significant difference in pain intensity when comparing the distraction-only group with the non-distracted control group ($t(36)=0.82$, $p>.05$, $d=0.31$)[2]. This pattern of results was further substantiated by another series of one tailed *t*-tests. First, there was no difference in pain intensity between high and low catastrophizers in the control group ($t(24)=-0.97$, $p>.05$, $d=0.38$). Second, low catastrophizers reported less intense pain than high catastrophizers in the distraction-only group ($t(22)=-2.04$, $p<.05$, $d=0.84$). Third, there was no significant difference in pain intensity between high and low catastrophizers in the motivated distraction group ($t(21)=-0.18$, $p>.05$, $d=0.07$).

Self-reported pain affect

Means and standard deviations of self-reported pain affect are presented in Table 2. An ANCOVA analysis with pain affect as dependent variable, group as between-subjects factor, and catastrophizing as covariate, showed no differences in pain affect between the three groups ($F<1$). There was a trend towards a main effect of catastrophizing on pain affect ($F(2,67)=3.15$, $p=.08$, $\eta p^2=.05$), indicating that higher levels of catastrophizing were associated with more unpleasantness. There was no interaction-effect of (catastrophizing x group) on pain affect ($F(2,67)=2.07$, $p>.05$, $\eta p^2=.06$).

[2] Note: An ANCOVA in which the control group was compared to the distraction-only group and catastrophizing was used as a continuous variable showed an interaction trend of (catastrophizing X group) ($F(1,46)=3.20$, $p=.08$, $\eta p^2=.07$). No such interaction was found when the control group was compared with the motivated-distraction group ($F(1,45)=0.84$, $p=.36$, $\eta p^2=.02$).

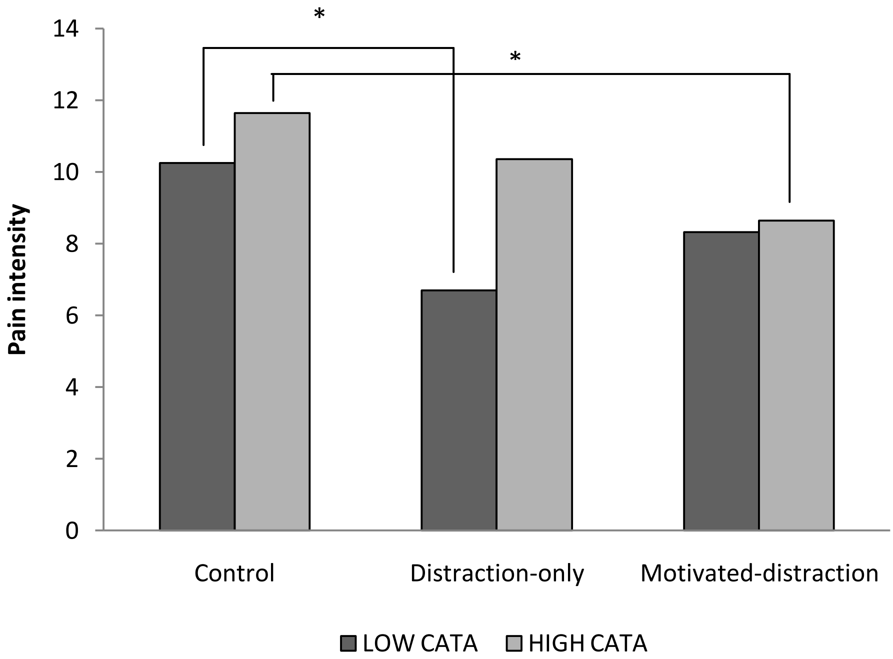

*Figure 1: Interaction between group and catastrophizing on pain intensity, *p<.05*

DISCUSSION

This study investigated whether the motivational relevance of a distraction task enhances the effectiveness of distraction. Participants were assigned to (1) a control group, (2) a distraction-only group, or (3) a motivated-distraction group. Findings can be summarized as follows. Results showed that, overall, participants in both distraction groups reported significantly less pain intensity compared to the control group. These results are consistent with other studies that also found similar beneficial effects of distraction on the pain experience (James & Hardardottir, 2002; Johnson, Breakwell, Douglas, & Humphries, 1998; Marchand & Arsenault, 2002; McCaul & Haugtvedt, 1982; Miron, Duncan, & Bushnell, 1989; Terkelsen, Andersen, MØlgaard, Hansen, & Jensen, 2004). However, our study has further value over previous studies. Participants were unaware that this experiment was about distraction from cold pressor pain, thereby minimizing possible demand and expectancy effects (Leventhal, 1992). This study also meets most of the methodological considerations raised by Eccleston (1995) including pain measurement, standardisation of the pain induction method and measurement of distraction task engagement. We also followed guidelines for the use and standardisation of the cold pressor test (von Baeyer et al., 2005). This distraction study clearly showed an effect of distraction on pain intensity of moderate effect size.

Of further importance was the finding that the effect of distraction on pain intensity appeared to be moderated by pain catastrophizing. In line with previous research, high catastrophizers in our study reported more attention to pain (Goubert et al., 2004; Van Damme et al., 2008) and more negative affect during pain (Van Damme et al., 2008). Our results further showed that distraction was not effective for high catastrophizers in the distraction-only group. This finding complements previous studies which also found no effects of distraction from pain for high catastrophizers (Goubert et al., 2004; Heyneman et al., 1990). However, those who catastrophize about pain do seem to benefit from distraction when the distraction task becomes motivationally relevant.

There are various explanations for the finding that distraction does not work for high catastrophizing participants, but appears to work when the motivation to perform the task is enhanced. First, research has shown that attention is unintentionally captured by painful stimuli that are intense (Eccleston & Crombez, 1999). It is possible that high catastrophizers' ability to distract from pain was hindered because their pain was more intense. A motivationally relevant task may then be needed to overrule the attentional capture by pain and obtain effects of a distraction task. Our results, however, do not support this idea. In our non-distracted control group, high catastrophizers did not rate the pain as more intense than low catastrophizers.

A more plausible explanation may be found in the idea that those who catastrophize, tend to worry or ruminate about pain during other tasks in many situations (Chapman, 1978), and that this negative mental set is not easily paused or stopped (Eccleston, Crombez, Aldrich, & Stannard, 2001). We have previously argued that when pain has become a primary concern of the mind, pain related information automatically captures attention (Crombez et al., 1998a; Crombez et al., 2005; Eccleston & Crombez, 2007; Klinger, 1996; Legrain, 2008; Van Damme et al., 2010). It may be that a simple distraction task is not sufficient to halt catastrophic thinking about pain and prevent the capture of attention by pain. A more motivationally relevant task may be needed to temporary inhibit or displace worrying about pain in order to fully engage in the distraction task. Indeed, adding a reward clearly increased the effort to perform the distraction task in the motivated-distraction group for both high and low catastrophizers.

These findings may have clinical implications. Attention management strategies are often used in pain treatment programs (Elomaa, Williams, & Kalso, 2009; Morley et al., 2004). Some researchers have suggested that the use of distraction protocols might be ineffective for high anxious patients and pain catastrophizers (Roelofs, Peters, van der Zijden, & Vlaeyen, 2004; Van Damme, Crombez, & Eccleston, 2002). Others have suggested that other attentional strategies, in which attention is drawn to the pain and pain is reinterpreted (i.e., sensory-focusing) are perhaps more fruitful for high anxious and high catastrophizing individuals (Heyneman et al., 1990; Roelofs et al., 2004). This study, however, shows that distraction might also be effective for high catastrophizers, on the condition that the distraction task is motivationally relevant.

This study has some limitations. First, the participants of this study were all undergraduate students, the painful stimulation was created and delivered in the laboratory, and there were no extreme levels of catastrophic thinking about pain. Further research is needed to demonstrate whether our results can be replicated with a non-student sample experiencing clinically relevant pain. Second, we found no effects of distraction on pain affect. This is not consistent with previous studies that have demonstrated effects on both pain affect and intensity (Meagher, Arnau, & Rhudy, 2001; Miron et al., 1989; Terkelsen et al., 2004), but is similar to studies which have shown that the manipulation of attention clearly alters pain intensity, but influences pain affect to a far lesser degree (Kenntner-Mabiala, Weyers, & Pauli, 2007; Keogh, Hatton, & Ellery, 2000; Villemure, Slotnick, & Bushnell, 2003). It is possible that our pain affect measure was less sensitive and therefore did not reach significance. Third, we used a distraction task that had theoretical advantages: It was attention-demanding (Vandierendonck et al., 1998), directed attention to an external cue (Johnson et al., 1998) and involved another perceptual modality (Villemure & Bushnell, 2002). The task was, however, not rated as very interesting. This offers a challenge for future research. It will be important to find ways to further enhance motivation in distraction tasks. One interesting idea might be to explore the use of feedback on task performance (Bonner & Sprinkle, 2002). Another major challenge for experimental as well as clinical populations, is to optimize distraction tasks in a way that they match personal and valued goals. Fourth, it is difficult to disentangle whether the distraction effects in our study are related to an enhanced motivation or to positive affect. It is possible that adding a reward to the distraction task has created a positive affect. Previous studies have shown that positive affect can diminish pain (de Wied & Verbaten, 2001; Meagher et al., 2001; Villemure et al. 2003). Such an explanation is however unlikely. Positive affect mainly alters pain affect, not pain intensity (Villemure et al., 2003), and we observed the reverse. Finally, the differential effects of motivation on distraction effectiveness for high and low catastrophizers are interesting, but further research is necessary to replicate our findings. Low statistical power might have resulted in the detection of moderate rather than small effect sizes.

ACKNOWLEDGEMENTS

The authors thank Lore Van Hulle and Ruben Callens for their assistance in the data input, Pascal Mestdagh for the technical support, and Julia Vogt for her insightful comments. Preparation of this paper was partly supported by Grant BOF/GOA2006/001 of Ghent University and FWO project G.017807.

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CHAPTER 4

THE ROLE OF PAIN CATASTROPHIZING IN DIRECTING ATTENTION AWAY FROM PAIN: AN EXPERIMENTAL ANALYSIS IN SCHOOLCHILDREN[1]

ABSTRACT

Distraction is an intuitive way of coping with pain, and is often used in children's pain treatment programs. However, empirical evidence concerning the effectiveness of distraction is equivocal. One potential explanation might be that distraction does not work for everyone in every situation. In the current series of studies, we examined the role of pain catastrophizing as an influencing factor of distraction effectiveness. In the first study, we investigated the use of pain coping strategies, including distraction, in schoolchildren by means of a questionnaire (*N*=828, aged 8-18 years). Results indicated that children with higher levels of pain catastrophizing reported using less distraction strategies in daily life than children with lower levels of pain catastrophizing. In the second study, a subsample (*N*=81, aged 9-18 years) performed a painful cold pressor task (CPT) (12 °C). Participants were randomly assigned to a distraction group, in which an attention-demanding tone-detection task was performed during the CPT, or a control group in which no distraction task was performed. Results showed that participants in

[1] Verhoeven, K., Goubert, L., Jaaniste, T., Van Ryckeghem, D.M.L., & Crombez, G. (submitted). The role of pain catastrophizing in directing attention away from pain: An experimental analysis in schoolchildren.

the distraction group were engaged in the distraction task, and reported paying less attention to pain than participants in the control group. However, distraction was ineffective in reducing cold pressor pain and even intensified the pain experience in high catastrophizing children. Caution may be warranted in using distraction as a one size fits all strategy, especially in high catastrophizing children.

INTRODUCTION

Pain is a common experience in children (Huguet & Miro, 2008; McGrath, 1990; Perquin et al., 2000). Distraction, or directing attention away from a noxious event and engaging attention in other activities or cognitions (Eccleston, 1995; Fernandez, 1986; Piira, Hayes, & Goodenough, 2002), is often used to cope with pain, and is part of many pain treatment programs (Powers, 1999). Several reviews on the effectiveness of distraction in children exist (Chambers, Taddio, Uman, & McMurtry, 2009; DeMore & Cohen, 2005; Kleiber & Harper, 1999; Piira, Hayes et al., 2002; Powers, 1999; Uman, Chambers, McGrath, & Kisley, 2008). Although they generally report small positive effects of distraction, results are heterogeneous across different pain outcome measurements (e.g., threshold, intensity, tolerance, distress), settings (e.g., clinical, laboratory), and those delivering the distraction (e.g., child, parents, nurses) (Chambers et al., 2009; Piira, Hayes et al., 2002; Uman et al., 2008). Heterogeneous findings may be the result of methodological problems in research designs (see Eccleston, 1995 for a review; Piira, Hayes et al., 2002), but they may also point to the role of moderating variables (Eccleston & Crombez, 1999; Kleiber & Harper, 1999). Research investigating influencing factors of distraction effectiveness in children, however, is scarce, but is necessary to gain more insight in the underlying processes of distraction in order to improve its use.

One possible moderating variable is the extent to which pain is experienced as threatening (Eccleston & Crombez, 1999). It has been shown that pain automatically attracts attention when it is highly threatening (Crombez, Eccleston, Baeyens, & Eelen, 1998a; 1998b). It is therefore reasonable to assume that engagement with a distraction task is more difficult in situations of threatening pain, making distraction less effective (Eccleston & Crombez, 1999; Van Damme, Crombez, Van Nieuwenborgh - De wever, & Goubert, 2008). The degree to which pain is experienced as threatening may depend upon individual differences in pain catastrophizing (i.e., having an exaggerated negative orientation towards actual or anticipated pain experiences) (Sullivan, Bishop, & Pivik, 1995). Indeed, high catastrophizing individuals are hypervigilant to pain stimuli and, particularly, have more difficulties disengaging attention from pain (Van Damme, Crombez, & Eccleston, 2004; Van Damme, Crombez, & Lorenz, 2007). It can therefore be expected that high catastrophizing individuals would experience more difficulties engaging in a distraction task during pain (Van Damme et al., 2008), making distraction less effective. This hypothesis has some support in students and adult pain patients (Goubert, Crombez, Eccleston, & Devulder, 2004; Heyneman, Fremouw, Gano, Kirkland, & Heiden, 1990; Verhoeven et al., 2010). In children, the relationship between catastrophizing and distraction has not yet been investigated.

The aims of this research were twofold. First, we examined the daily use of distraction and its relationship with pain catastrophizing in schoolchildren by means of a questionnaire. Second, we examined the effectiveness of distraction in a laboratory cold pressor study, in which schoolchildren were randomly assigned to either a distraction group, which performed an attention-demanding distraction task during the immersion of their hand in cold water, or a control group, which performed no distraction task. We expected (1) that the use of distraction in daily life decreases with increasing levels of pain catastrophizing, and (2) that distraction is less effective in reducing pain in high catastrophizing children. Additionally, we also explored age and sex differences.

STUDY 1

METHOD

Participants

Seventeen schools in Gent (Belgium) were contacted. Eight schools, with a total population of 2086 children, agreed to participate. The main reason for schools refusing to participate was a lack of time. Of the 2086 children and parents approached, 882 children agreed to participate, 961 children did not return the informed parental consent forms, and 243 children refused to participate. Eight hundred twenty-eight children (94%) actually participated (437 girls, age range 8-18 years, M_{age}=12.44 years, *SD*=2.19). Illness was the most common reason for declining. A total of 8.8% of the children were recruited from grade 4 (*N*=73); 9.4% from grade 5 (*N*=78); 11.1% from grade 6 (*N*=92); 19.2% from grade 7 (*N*=159); 23.6% from grade 8 (*N*=195); 10.7% from grade 9 (*N*=89); 8.5% from grade 10 (*N*=70); 4.3% from grade 11 (*N*=36) and 4.3% from grade 12 (*N*=36). There were no inclusion and exclusion criteria specified. The study was approved by the ethical committee of the Faculty of Psychology and Educational Sciences of Ghent University. Written informed parental consent was obtained. Children aged 12 years and above also signed informed consent.

Measures

Subject characteristics

Participants' pain characteristics were assessed with six items that were based on the Varni-Thompson Pediatric Pain Questionnaire (PPQ; Varni, Thompson, & Hanson, 1987). Participants were asked to indicate whether they had experienced pain during the past two weeks. If this question was answered affirmatively, participants were asked to indicate the pain locations on a manikin figure. Pain locations were coded in the following categories: Head, arms, legs, stomach, back, or other parts of the body. Overall pain intensity (0="a little bit" to 3="very much") and frequency (0="once" to 3="all the time") were also assessed. Participants indicated on a visual analogue scale (VAS) the present pain ("present pain intensity") and the worst pain they experienced during the last two weeks ("most severe pain intensity") (0="no pain",100="very much pain"). We calculated a "pain severity" measure by averaging the "present pain intensity" and the "most severe pain intensity" scores (see Vervoort, Goubert, Eccleston, Bijttebier, & Crombez, 2006).

Pain catastrophizing

Pain catastrophizing was assessed with the Dutch version of the Pain Catastophizing Scale for Children (PCS-C; Crombez et al., 2003). This questionnaire is an adapted version of the Pain Catastrophizing Scale (PCS) (Crombez et al., 1998b; Sullivan et al., 1995). The PCS-C contains 13 items that measure children's thoughts and feelings when they are in pain (e.g., "When I have pain, I keep thinking about other painful experiences") on a 4-point scale (0="not at all"; 4="very much"). Total scores range from 0 to 52. The PCS-C has demonstrated good construct, internal and predictive validity in children aged 9 to 15 years (Crombez et al., 2003). In this study, Cronbach's alpha was .87.

Pain coping

Pain coping was assessed with the Dutch version of the Pain Coping Questionnaire (PCQ; Bandell-Hoekstra et al., 2002; Reid, Gilbert, & McGrath, 1998), consisting of 39 items that measure children's pain coping strategies. The PCQ has demonstrated good internal reliability and test-retest reliability in healthy children and children with chronic pain (Bandell-Hoekstra et al., 2002; Hermann, Hohmeister, Zohsel, Ebinger, & Flor, 2007; Reid et al., 1998). Participants were given the following prompt: "When I am hurt or in pain for a few hours or days, I…", and were asked to indicate how often they use several pain coping strategies on a 5-point scale (0="never"; 1="almost never"; 2="sometimes"; 3="often"; 4="very often"). The PCQ contains eight subscales: (1) *Behavioral distraction* (four items, e.g., "Do something fun"), (2) *Cognitive distraction* (six items, e.g., "Put it out of my mind"), (3) *Information seeking* (four items, e.g., "Ask questions about the problem"), (4) *Problem-solving* (five items, e.g., "Think about what needs to be done to make things better"), (5) *Seeking social support* (five items, e.g., "Talk to someone about how I am feeling"), (6) *Positive self-statements* (five items, e.g., "Say to myself, be strong"), (7) *Externalising* (five items, e.g., "Argue and fight"), and (8) *Internalizing/catastrophizing* (five items, e.g., "Think that the pain will never stop"). Because of the conceptual overlap between the subscale internalizing/catastrophizing of the PCQ and the catastrophizing measure of the PCS (r=.66, p<.001), we only examined the relationship between the PCS and the seven other subscales of the PCQ.

Procedure

Schools were first contacted by letter, then by phone. When the principal consented, parents were given a letter explaining the purpose of this study (i.e., examining pain experience in children), and an informed consent form. Children were allowed to participate if a signed parental informed consent and child assent (for children 12 years and above) was obtained. The PCS, PCQ and PPQ, together with a battery of other questionnaires, which were of no relevance for this study, were administered in the classroom during regular school hours in the presence of a research assistant. Participants received information about the study at the beginning of the test session and provided informed consent. They were informed they could end the test session at all times. Instructions were presented at the top of each questionnaire, complemented with oral clarification by the research assistant. Completion of the questionnaire battery took approximately 45 minutes.

RESULTS

Sample characteristics

Descriptive analyses indicated that the majority of the sample experienced some type of pain during the two weeks prior to the study (86%). Pain intensity was mostly described as low (29%) or moderate (50%). Leg pain (38%), headache (29%), and pain in other parts of the body (56%) were most frequently reported (e.g., neck, shoulder or feet). The majority of the sample reported having experienced pain once (24%) or a few times (57%) during the past two weeks. At the moment of testing, 26% reported to be pain free; most participants reported some type of pain (including pain resulting from a cold, bumps and bruises), that was of low intensity (M=24.65, SD=23.79, range 0-100). Pain severity was positively correlated (Pearson) with pain catastrophizing (M=12.20, SD=7.73, range 0-48) (r=.28, p<.001), but not with age (r=-.04, p>.10). Independent sample t-tests showed no significant difference in pain severity between boys and girls ($t(812)$=1.31, p>.10, d=0.09).

Pain coping

The relationship between pain catastrophizing and the use of different pain coping strategies, was first examined with Pearson correlations. Means and standard deviations of pain coping strategies and correlations with pain catastrophizing are presented in Table 1. Results showed a negative association between pain catastrophizing and the use of behavioural and cognitive distraction (all p<.01). A positive association was found between catastrophizing and the use of all other coping strategies (all p<.01), with the exception of positive self-statements which showed no association with catastrophizing (p>.10).

Next, a series of hierarchical multiple regression analyses was conducted to examine the relationship between pain catastrophizing and the use of different pain coping strategies, in particular distraction strategies, as this was the main focus of the research. We also explored age and sex differences, and controlled for pain severity. In the first block, we entered age, sex (boys coded as -1, girls coded as 1), and pain severity. Catastrophizing was entered in the second block. Variance inflation factors were small (1.01-1.10), indicating that there was no problem of multicollinearity. Results are presented in Table 2. Results showed a significant effect of age on the use of cognitive distraction, indicating that the use of this technique increases with age. The use of behavioural distraction was independent of the child's age. A significant effect of sex was found on the use of cognitive as well as behavioral distraction, indicating that these strategies were more often used by boys than girls, who in turn reported seeking more social support. No effect of pain severity on the use of distraction techniques was found. Finally, and most importantly, a significant effect of pain catastrophizing on the use of behavioural and cognitive distraction strategies was found, indicating that with increasing levels of pain catastrophizing, less use is made of these coping strategies.

Table 1

Means (M) and standard deviations (SD) of PCQ subscales scores and correlations (r) with pain catastrophizing

PCQ subscales	Range	α	M (SD)	PCS (r)
Behavioral distraction	0-16	.81	8.71 (3.57)	-.21**
Cognitive distraction	0-24	.81	13.25 (4.97)	-.16**
Information seeking	0-16	.65	5.07 (2.91)	.35**
Problem-solving	0-20	.84	8.47 (4.26)	.37**
Seeking social support	0-20	.87	8.61 (4.92)	.28**
Positive self-statements	0-20	.85	10.50 (4.74)	.05
Externalising	0-20	.83	3.05 (3.65)	.23**

Note: PCS=Pain Catastrophizing Scale; PCQ=Pain Coping Questionnaire; ***p*<.01.

Table 2

Hierarchical regression analyses with age, sex, pain severity, and catastrophizing as independent variables, and pain coping strategies as criterion variables

Criterion variables	Step	Predictor	β	ΔR²
Cognitive distraction	**1**	**Age**	.18***	.05***
		Sex	-.11**	
		Pain severity	-.04	
	2	**Catastrophizing**	-.12**	.01**
Behavioral distraction	**1**	**Age**	-.02	.05***
		Sex	-.18***	
		Pain severity	.02	
	2	**Catastrophizing**	-.17***	.03***
Information seeking	**1**	**Age**	.09**	.01*
		Sex	.001	
		Pain severity	-.07	
	2	**Catastrophizing**	.36***	.12***
Problem-solving	**1**	**Age**	.20***	.05***
		Sex	.02	
		Pain severity	-.07	
	2	**Catastrophizing**	.38***	.13***
Seeking social support	**1**	**Age**	.05	.11***
		Sex	.28***	
		Pain severity	-.06	
	2	**Catastrophizing**	.26***	.06***
Positive self-statements	**1**	**Age**	.16***	.03***
		Sex	-.02	
		Pain severity	-.09*	
	2	**Catastrophizing**	.08*	.01*
Externalizing	**1**	**Age**	.12***	.07***
		Sex	-.01	
		Pain severity	.19***	
	2	**Catastrophizing**	.19***	.03***

Note: Standardized betas of the last step are displayed,**p*<.05; ***p*<.01;****p*<.001.

DISCUSSION

This study has shown that children indeed use cognitive and behavioural distraction to cope with pain in daily life. The use of cognitive distraction appears to increase with age. This finding is in line with previous research that has shown the use of cognitive coping strategies in general, and the use of cognitive distraction in particular, to increase with age (Altshuler & Ruble, 1989; Bennett-Branson & Craig, 1993; Branson & Craig, 1988; Curry & Russ, 1985; Hodgins & Lander, 1997; Lynch, Kashikar-Zuck, Goldschneider, & Jones, 2007). However, other studies, which have also used the PCQ, found no differences in the use of cognitive distraction with age (Lu, Tsao, Myers, Kim, & Zeltzer, 2007; Piira, Taplin, Goodenough, & von Baeyer, 2002). Our study, however, consisted of a much larger sample, with a large number of participants in different age categories, which might have facilitated the detection of age effects. Cognitive, as well as behavioral distraction strategies were found to be used more often in boys than girls, who in turn reported seeking more social support. These findings support previous research, which has found similar sex differences (Lu et al., 2007; Lynch et al., 2007). Finally, and most importantly, our results showed a negative association between pain catastrophizing and the use of distraction. A positive association was found between catastrophizing and the use of all other pain coping strategies. This may indicate that when pain catastrophizing is high, children are less likely to distract themselves and divert attention away from pain, but rather seem to adopt coping strategies that are focussed on the pain (e.g., try to find solutions for their pain, seek information about the pain, and talk about the pain). This finding is in line with previous research in adults that has shown a positive association between pain catastrophizing and a coping style that is directed at trying to resolve the problem and control the pain (De Vlieger, Van den Bussche, Eccleston, & Crombez, 2006; Eccleston & Crombez, 2007). High catastrophizing children might use certain coping strategies because of their inability to disengage attention from pain (Van Damme et al., 2004; Van Damme et al., 2007). Results should however be interpreted with caution. Correlations indicated rather small effects and do not allow a causal inference.

To test whether distraction is actually less effective for high catastrophizing children, a subsample of the participants of study 1 participated in a laboratory cold pressor experiment, in which we examined the role of pain catastrophizing as an influencing factor of distraction effectiveness.

STUDY 2

METHOD

Participants

The majority of the schoolchildren who participated in study 1 consented to be re-contacted for participation in a subsequent study (91%). From this pool, 117 schoolchildren between the ages of 9 and 18 years were randomly selected (by computerized lottery) to participate in a cold pressor experiment. Twenty-two of them refused to participate, mainly because of lack of time or interest. Five of them met one of the exclusion criteria: Raynaud's disease, heart conditions, cuts, sores or fractures on the hand that had to be immersed, epilepsy, chronic pain (*N*=2), developmental disorders, color blindness, dyslexia (*N*=1), or previous experience with the cold pressor task (*N*=2) (von Baeyer, Piira, Chambers, Trapanotto, & Zeltzer, 2005). Ninety children remained, but due to scheduling problems and time constraints, only 87 actually participated (97%). All participants were of Belgian nationality, reported good to excellent health, and noted no psychological problems. The minority of the sample reported minor medical problems (16%), in most cases allergies, asthma and occasional back pain complaints. Sixty-nine percent of the children's parents was married or co-habiting. Seventy percent of the mothers and 64% of the fathers were higher educated (beyond the age of 18 years).

Children and parents participated voluntarily and received a financial reimbursement to cover transport costs (25 euro). Both provided a written informed consent and were fully debriefed after the experiment. The experiment was approved by the ethical committee of the Faculty of Psychology and Educational Sciences of Ghent University.

Material and measurements

Sample descriptive

A questionnaire was used to assess socio-demographic sample characteristics of children (e.g., sex, age) and parents (e.g., education level, current profession, family situation). Psychological and physical health of the child was also included in this questionnaire.

Children's pain characteristics prior to the testing were assessed with the same six items which were used in study 1 (PPQ; Varni et al., 1987).

Pain catastrophizing

Similar to study 1, pain catastrophizing was assessed with the Pain Catastrophizing Scale for Children (PCS-C; Crombez et al., 2003). In this study, Cronbach's alpha was .83.

Cold pressor task (CPT)

Children participated in a pain-inducing CPT. The cold pressor apparatus used was a metallic water container (type Techne B-26 with TE-10D, size 53 x 32 x 17 cm). A circulating water pump (type Techne Dip Cooler RU-200) was used to prevent heat formation around the immersed hand (von Baeyer et al., 2005). We used a fixed immersion paradigm, in which children were asked to immerse their hand for 1 minute, instead of a tolerance paradigm (see Verhoeven et al., 2010). A tolerance paradigm is less useful in experiments with children with a broad age range, as younger children tend to endure the cold pressor test for a shorter period of time than do older children (Jaaniste, Hayes, & von Baeyer, 2007). By using a fixed immersion interval we avoided that our self-reported measure of pain was confounded by tolerance time. As a result, all participants were exposed to the same physical stimulation. The water temperature was kept constant at 12 °C. Previous research has revealed that this temperature and 1 minute immersion interval creates a painful stimulus of moderate pain intensity which is suitable for investigating distraction effects (Verhoeven et al., 2010). A highly intense pain stimulus was considered undesirable in this experiment, because distraction is argued to fail for high intense pain (Eccleston & Crombez, 1999).

Another container filled with room temperature water of 21 °C was used to standardize hand temperature before the immersion in the cold water bath (type Julabo TW20, size 56 x 35 x 32 cm) (von Baeyer et al., 2005).

Distraction task

The distraction task used was the Random Interval Repetition task (RIR; Vandierendonck, De Vooght, & Van der Goten, 1998a; 1998b). The RIR-task is a well validated tone-detection task, of which research has shown that it is attention-demanding (Vandierendonck et al., 1998a; 1998b), and suitable as a distraction task (Goubert et al., 2004; Van Damme et al., 2008; Verhoeven et al., 2010). Participants were instructed to respond as quickly as possible to tones (tone duration=150 ms; tone pitch=750 Hz) generated by a computer (ASUS L2000). Responses were given by means of a button pressing device, held by the participants in their right hand. In this experiment we used an adaptation of the original RIR-task. In the original task tones are presented at stimulus-stimulus interval, with a randomly chosen inter stimulus interval of 900 or 1500 ms. Younger children, however, may need more time to respond to the tones compared to older children, leaving them with less time to cognitively prepare for the next tone. Therefore, we presented the tones at response-stimulus intervals. The next tone was presented at a random stimulus interval of 900 or 1500 ms after responding to the previous one. By giving everyone an equal amount of time to prepare for the next tone, we made the task equally difficult for children of all ages. Tones were presented through headphones (Sony MDR-V150). In this study, the total RIR-task duration was 1 minute.

It has been argued that distraction may only work when the distraction task is motivationally relevant (Van Damme, Legrain, Vogt, & Crombez, 2010). Therefore a financial reward was given to enhance the motivation to perform the distraction task (see Verhoeven et al., 2010). Financial rewards are considered to be very influential and are often used to increase motivation in experimental research in adults and children (Bonner & Sprinkle, 2002; Kohls, Peltzer, Herpertz-Dahlmann, & Konrad, 2009). Research has shown that the interest in, and the understanding of money rapidly increases between the ages of 5 and 7, and is fully established at the age of 8 (Berti & Bombi, 1981; Grunberg & Anthony, 1980). In this study, participants could win 10 eurocents every time they pressed the button quickly and accurately. If the response was given too late or inaccurately, they could lose 10 eurocents. After the experiment, participants received 3, 4 or 5 euro for their task performance. This amount was randomly assigned and was unrelated to the actual task performance.

Distraction task engagement

Task performance served as a behavioural measurement of distraction task engagement. We calculated participants' reaction time (RT) and response variation (SD), excluding anticipations (RTs < 100 ms), non-responses and outliers (RTs > 3 SD above the individual mean) (Goubert et al., 2004; Van Damme et. al., 2008; Verhoeven et al., 2010). Errors were calculated by summing the number of anticipations and non-responses.

Self-reported distraction task engagement was examined with two items. Children in the distraction group were asked to indicate how much "attention they paid to the task" and how "important it was for them to perform the task well". All items were scored on a 0 to 100 mm VAS, labelled at 0 mm ("not at all"), 25 mm ("a little bit"), 50 mm ("quite a bit"), 75 mm ("a lot") and 100 mm ("very much").

Self-reported attention to pain

Attention to pain was assessed by means of two items that measure the same construct, but were opposite in formulation to control for response tendency. Participants were asked to indicate on a 100 mm VAS how much attention they paid to the pain, and the degree to which they were able to distract from the pain during the CPT. The scale was labelled at 0 mm ("not at all"), 25 mm ("a little bit"), 50 mm ("quite a bit"), 75 mm ("a lot") and 100 mm ("very much"). An "attention to pain" score was calculated by subtracting the ability to distract from pain from the amount of attention paid to pain (range -100 to +100). The higher the score, the more attention was paid to pain during the CPT.

Self-reported pain during cold pressor task (CPT)

Pain experience during the CPT was assessed through self-report. A distinction was made between pain intensity and pain affect (Price, 2000). Pain intensity was assessed with two items. Participants were asked to indicate the "worst pain" and the "pain just before the end of the immersion" on a 100 mm VAS, labeled at 0 mm ("no pain"), 25 mm ("low pain"), 50 mm ("moderate pain"), 75 mm ("most intense pain") and 100 mm ("enormous pain"). According to Kahneman and colleagues (1993), these two measures are valid indicators of the pain experience during the CPT. A total pain intensity score was calculated by adding the two pain intensity items (range 0-200). Pain affect was assessed with two items. Participants were asked to indicate how unpleasant the cold pressor experience was, and how anxious/tense they were feeling during the immersion on a 100 mm VAS from -50 ("relaxed/pleasant") to +50 ("very anxious/unpleasant"). A total pain affect score was calculated by adding the two pain affect items (range -100 to +100).

Experimental manipulation

Participants were randomly (by means of a computerized program) assigned to one of two groups: (1) A distraction group (N=42, 20 girls, M_{age}=13.57 years, SD=2.56, range 9-18 years), in which attention to pain during the CPT was manipulated using an attention-demanding tone-detection task, and (2) a control group (N=45, 24 girls, M_{age}=13.36 years, SD=2.71, range 9-18 years), in which no distraction task was performed during the CPT.

Procedure

Parents were contacted by phone and were given standardized information about the experiment. They were informed that their child would be asked to immerse the left hand in a cold water tank for 1 minute. They were also told that their child would be asked to complete several questionnaires, and perform several cognitive tasks. Parents were informed that their child was allowed to stop the experiment at all times, and that they would be reimbursed for transportation costs. When parents and child consented, and if the child did not meet any of the exclusion criteria, an appointment was made.

On arrival, participating children and their parents received information about the experiment, and provided informed consent. Children were told that they would be asked to complete several questionnaires, perform several cognitive tasks (which were of no relevance for this study), and perform the CPT, which was described as a safe and often used method in pain research. Participants were told that the aim of this experiment was to investigate pain experience, and were uninformed that this experiment was about distraction from cold pressor pain. That way, potential placebo effects were kept at a minimum (Benedetti, 2006; Leventhal, 1992; Vase, Riley, & Price, 2002). While the children completed the experiment, parents completed a socio-demographic questionnaire in the adjacent room. After completing the cognitive tasks - which took about 30 minutes - children received standard information about the cold pressor procedure and immersed their left hand for 1 minute in the room temperature tank to standardize hand temperature (von Baeyer et al., 2005). Before the cold water immersion, children in the distraction group received information about the distraction task. Children were instructed to *"focus on the task during immersion"* and were informed that *"it was important to perform the task well"*. They were instructed that *"they could earn 10 eurocent every time they pressed the button quickly and accurately, and lose 10 eurocent every time they pressed the button too late or inaccurately, with the possibility to earn a maximum of 6 euro, which they would receive at the end of the experiment"*. Children in the control group were instructed to *"keep their thoughts on the cold water and the pain they experienced"* (Leventhal, Brown, Shacham, & Engquist, 1979). Finally, children in both groups were instructed to *"immerse their hand and wrist, not to form a fist and not to move their fingers"* (von Baeyer et al., 2005). After the instructions, children immersed their left hand in the cold water container for 1 minute. Immediately following the cold water immersion, they answered the questions about the pain experienced (Koyama, Koyama, Kroncke, & Coghill, 2004). Children in the distraction group also completed the questions about the distraction task. The cold pressor procedure ended with a submersion of 1 minute in the room temperature tank to recover (von Baeyer et al., 2005). During the CPT the researcher stayed in the room, and was sitting behind a screen to minimize contact with the child. The child was unable to see the researcher, who in turn was able to observe the child during immersion. After the CPT, parents and child were reunited, and fully debriefed.

Data analysis

Six children were excluded from the analyses: Two children did not endure the CPT for 1 minute (11 year old boy, control group; 12 year old girl, distraction group), one child was excluded because of a high number of distraction task errors (3 SDs above the group error mean), and three children were excluded as a result of technical problems. Statistical analyses were conducted on the remaining 81 participants (42 girls, M_{age}=13.60 years, *SD*=2.64, 98% Caucasian).

For data analysis SPSS 15.0 was used. First, distraction task engagement was examined with descriptive analyses. We also examined the relationship with pain catastrophizing, and explored age and sex differences. Second, a series of hierarchical regression analyses was executed to examine the relationship between pain catastrophizing and distraction. We also explored effects of age and sex. In these analyses, dependent variables were attention to pain, pain intensity and pain affect. In the first step, age and sex (boys coded as -1, girls coded as 1) were entered. In the second step, we entered group allocation (control group coded as -1, distraction group coded as 1) and catastrophizing. In the third step, the interaction terms of (group x catastrophizing), (group x age), and (group x sex) were entered. All continuous variables were centred (Aiken & West, 1991). Effect sizes were calculated by using Cohen's *d* (0.20 "small", 0.50 "medium" or 0.80 "large" effects) (Cohen, 1988).

RESULTS

Sample characteristics

Descriptive analyses indicated that 78% of the sample experienced pain during the two weeks prior to the experiment, which was mostly of low (37%) or moderate (52%) intensity. Leg pain (35%), stomach ache (16%) and pain in other parts of the body (25%) were most prevalent (e.g., knee, neck, feet). Pain was generally experienced once (32%), or a few times (57%) during the past two weeks. At the moment of testing, 51% reported to be pain free, other participants reported some type of pain (including pain resulting from a cold, bumps and bruises), that was of low intensity (*M*=16.50, *SD*=19.06, range 0-100). Pain severity was not correlated (Pearson) with age or catastrophizing (*M*=12.15, *SD*=6.00, range 1-27) (all $r<.17$, all $p>.10$). Independent sample *t*-tests furthermore revealed no differences in pain severity ratings between boys and girls ($t(61)=-1.38$, $p>.10$, $d=0.35$).

Independent sample *t*-tests showed no differences in pain severity, age, and pain catastrophizing between the control group and the distraction group (all $t<1.1$, $p>.10$, $d<0.26$). Both sexes were equally distributed across the two experimental groups ($\chi^2(1)=0.28$, $p>.10$).

Distraction task engagement

Descriptive analyses were conducted on distraction task performance measures (reaction times, response variation and errors) and self-reported distraction task experience measures (attention to task, importance to perform the task). Results indicated that the distraction task was performed accurately, with little errors (Reaction times: $M=284$ ms, $SD=73$ ms; Response variation: $M=73$ ms, $SD=27$ ms; Errors: $M=2\%$, $SD=2\%$). Pearson correlations showed a negative association between response variation and age ($r=-.38$, $p<.05$), indicating that with increasing age, response variation decreased. Reaction times and the amount of errors were independent of the child's age (all $r<.25$, $p<.10$). Further, no relationship was found between distraction task performance measures and pain catastrophizing ($r<.13$, $p>.10$). Independent sample *t*-tests showed no difference in distraction task performance measures between boys and girls (all $t<1$, $p>.10$, $d<0.35$).

Descriptive analyses furthermore indicated that participants reported to have paid attention to the task ($M=76$, $SD=28$), and found it moderately important to perform the task well ($M=55$, $SD=24$). Self-reported distraction task experience measures were not correlated with pain catastrophizing and age (all $r<.23$, $p>.10$). Independent sample *t*-test showed no difference in distraction task experience between boys and girls (all $t<1$, $p>.10$, $d<0.06$).

Attention to pain

To check whether our distraction manipulation was successful, we performed a hierarchical regression analysis, with attention to pain as the dependent variable. We also explored effects of age and sex (see Table 3). Results showed that participants in the distraction group reported to have paid significantly less attention to pain ($M=-35$, *SD*=38, *min*=-100, *max*=25) than participants in the control group (*M*=20, *SD*=36, *min*=-51, *max*=100) (*t*=-6.58, *p*<.001, *d*=1.49), indicating that our distraction manipulation was indeed successful. No main effects of catastrophizing, age, sex, or interaction-effects were found on attention paid to pain (all *t*<1.6, all *p*>.10).

Table 3

Hierarchical regression analyses with age, sex, group and catastrophizing as independent variabels and attention to pain, pain intensity and pain affect as criterion variables

Criterion variables	Step	Predictor	β	ΔR^2
Attention to pain	**1**	**Age**	.08	.02
		Sex	.07	
	2	**Group**	-.60***	.36***
		Catastrophizing	.01	
	3	**Catastrophizing x Group**	.02	.02
		Age x Group	-.15	
		Sex x Group	-.06	
Pain intensity	**1**	**Age**	-.02	.00
		Sex	-.06	
	2	**Group**	-.01	.07
		Catastrophizing	.29*	
	3	**Catastrophizing x Group**	.26*	.10*
		Age x Group	-.13	
		Sex x Group	-.16	
Pain affect	**1**	**Age**	.04	.01
		Sex	.01	
	2	**Group**	-.05	.03
		Catastrophizing	.15	
	3	**Catastrophizing x Group**	.12	.07
		Age x Group	-.24*	
		Sex x Group	.01	

Note: Standardized betas of the last step are displayed,**p*<05; ***p*<.01;****p*<.001.

Pain experience

To examine the effectiveness of distraction, and the moderating role of catastrophizing on pain intensity and pain affect, two separate hierarchical regression analyses were performed with pain intensity and pain affect as dependent variables. We also explored effects of age and sex (see Table 3). Results showed that pain intensity was not influenced by age or sex (all *t*<1, *p*>.10). There was no significant difference in pain intensity between the distraction group (*M*=94, *SD*=45, *min*=10, *max*=200) and the control group (*M*=93, *SD*=45, *min*=17, *max*=186) (*t*<1, *p*>.10, *d*=0.02). However, the significant interaction-effect of (catastrophizing x group) on pain intensity (t=2.31, p<.05) indicated that the experienced level of pain in the distraction and the control group depended upon the level of pain catastrophizing. To further explore this interaction-effect, we followed the procedure of Holmbeck (2002) for post-hoc probing of significant moderational effects. Analyses indicated that, in the distraction group, catastrophizing had a significant effect on pain intensity (t=3.44, β=.52, p<.01). In the control group, no effect of catastrophizing on pain intensity was found (t=0.16, β=.02, p>.10). To visualize the interaction-effect, we divided the sample into high (M+1SD, N=15) and low pain catastrophizers (M-1SD, N=14). Group means are presented in Figure 1. Results showed that distraction was not effective in reducing pain intensity in low catastrophizing children (M_{contr}=86, SD= 41; M_{distr}=69, SD=24; $t(12)$=0.78, p>.10, d=0.46), and even intensified the pain experience in high pain catastrophizing children (M_{contr}=83, SD=57; M_{distr}=132, SD=29; $t(13)$=-0.24, p<.05, d=1.22).

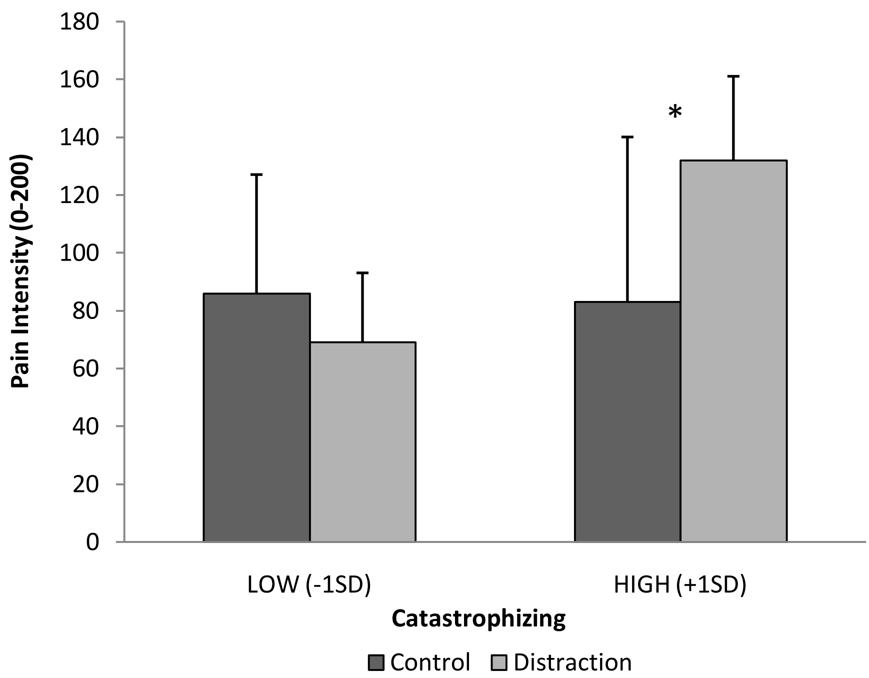

*Figure 1: Interaction-effect of group x catastrophizing on pain intensity; *p<.05*

Results further indicated that pain affect was not influenced by age and sex (all $t<1$, $p>.10$). There was no significant difference in pain affect between the distraction (M=12, SD=33, min=-80, max=71) and the control group (M=14, SD=39, min=-60, max=90) (t=-0.41, $p>.10$, d=0.06). No main effect of catastrophizing, or interaction-effect of (catastrophizing x group) was found on pain affect (all $t<1.4$, $p>.10$). Finally, a significant interaction-effect of (group x age) was found on pain affect (t=-2.12, $p<.05$). To further explore this interaction-effect we followed the procedure of Holmbeck (2002) for post-hoc probing of significant moderational effects. Results showed that age did not have an impact on pain affect in the distraction group (t=-1.39, β=-.23, $p>.10$) or control group (t=1.91, β=.28, p=.06). To visualize this interaction-effect, we divided the sample into three age groups (group 1: 9-11 years, group 2: 12-14 years, group 3: 15-18 years). Means are presented in Figure 2. For all different age groups, no significant differences in pain affect were found between the distraction and control group (all $t<1.7$, $p>.10$, $d<0.81$).

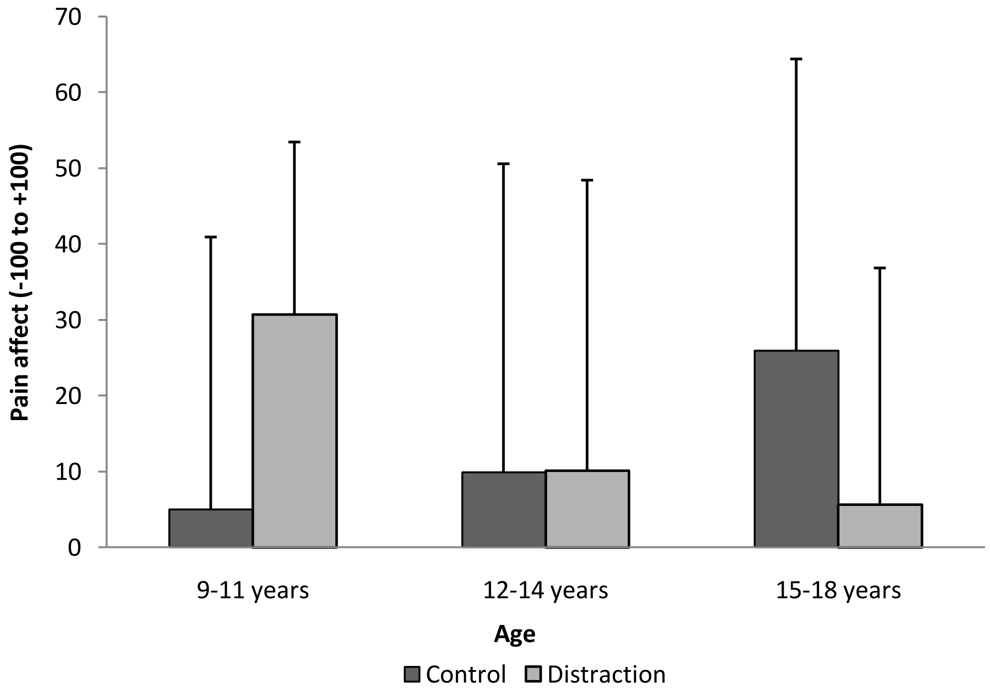

Figure 2: Interaction-effect of group x age on pain affect

DISCUSSION

Participants in the distraction group were engaged in the distraction task, and reported significantly less attention to pain than participants in the control group. This indicates that our distraction manipulation was indeed successful. Distraction was however inefficient in reducing pain intensity or pain affect during a cold pressor task. These findings are not in line with studies which have found beneficial effects of distraction (e.g., Kleiber & Harper, 1999; Uman et al., 2008; Vessey, Carlson, & McGill, 1994), but are in line with studies which have found no effects of distraction (e.g., Arts et al., 1994; Carlson, Broome, & Vessey, 2000; Cassidy et al., 2002; Jaaniste et al., 2007; Manne, Redd, Jacobsen, Gorfinkle, & Schorr, 1990). This indicates that distraction is not always effective, and moderating variables may play an important role. The present study indeed shows that pain catastrophizing is an important moderating factor in the effectiveness of distraction. Distraction is found to be ineffective in low catastrophizing children, and even intensifies the pain experience in high catastrophizing children. Besides catastrophizing, age also seems to play a role in the effectiveness of distraction. In older children, distraction appears to decrease pain affect, whereas in younger children distraction appears to increase pain affect. Results were however not significant, which might be due to large standard deviations and a low number of children in the youngest distraction group. Nevertheless, this study clearly shows that influencing factors should be taken into account when studying distraction effects.

GENERAL DISCUSSION

The aims of this research were (1) to investigate the daily use of distraction and its relationship with pain catastrophizing in schoolchildren, and (2) to examine the effectiveness of distraction, and the moderating role of pain catastrophizing in an experimental context. Our findings showed that high catastrophizing children use less distraction in daily life, and distraction even intensified the pain experience in high catastrophizing children during a laboratory cold pressor task.

For high catastrophizing children, the ineffectiveness of distraction could have been expected, as adult research clearly showed distraction to be ineffective for high catastrophizing individuals (Goubert et al., 2004; Heyneman et al., 1990). The finding that distraction even intensified the pain experience in high pain catastrophizing children was, however, surprising, making this study, to our knowledge, the first to show counterproductive effects of distraction on pain intensity in children. As yet, we do not have a full explanation. It is possible that those who catastrophize about pain, prefer to attend to and monitor pain, instead of disengaging attention from pain (Chapman, 1978; Eysenck, Derakshan, Santos, & Calvo, 2007). Engaging in a distraction task may then hamper their primary goal of attending to the pain, and create frustration and arousal, which in turn - if attributed to the painful stimulus - can enhance the pain experience (McCaul, Monson, & Maki, 1992). However, our data do not fully support this idea, as we did not find an increase in pain affect in those who catastrophize about pain.

For low catastrophizing children, the ineffectiveness of distraction was rather unexpected. Especially, because the distraction procedure that was used, has proven to reduce pain intensity in a student population (Verhoeven et al., 2010). This shows that distraction is not always effective in terms of pain reduction, and influencing factors should be taken into account. For instance, it has been argued that the attentional capture by pain - and as a result the effectiveness of distraction - depends upon the dynamic interplay between top-down and bottom-up influences (Eccleston & Crombez, 1999; Legrain et al., 2009; Van Damme et al., 2010). Examples of top-down influences are for instance goal-pursuit and goal-shielding (Van Damme et al., 2010). The prioritization of goals - here pain processing or the engagement with the distraction task - will result in the allocation of attention towards information that is important for the pursuit of these goals, other information will be inhibited. Which goal is prioritized may differ between and within persons, depending upon the situation (Van Damme et al., 2010). Processes that are important in goal-pursuit are attentional load and attentional set (Legrain et al., 2009). Attentional load refers to the amount of attention that is invested in a prioritized goal (Legrain et al., 2009). Attentional set refers to the mental set of stimulus features that are used to identify goal-relevant information (Legrain et al., 2009). Examples of bottom-up influences are for instance characteristics of the pain (e.g., pain novelty, intensity, treat) (Eccleston & Crombez, 1999). It can be expected that distraction is less effective in situations in which the pain is intense, experienced as threatening and novel, as pain automatically attracts attention in these situations. All of these bottom-up and top-down factors can influence the effectiveness of distraction. In this particular study, for instance, it is possible that distraction was ineffective because the pain was too intense. This is however unlikely because pain ratings in our study were moderate. Another explanation might be found in the distraction task used. Theoretically, the distraction task used in this study had the necessary qualities to be effective in reducing pain. It was attention-demanding (Vandierendonck, 1998a; 1998b), directed attention to an external cue (Johnson, Breakwell, Douglas, & Humphries, 1998), involved another perceptual modality (Villemure & Bushnell, 2002), was made motivationally relevant (Van Damme et al., 2010), and has been used successfully in previous distraction research (Goubert et al., 2004; Van Damme et al., 2008; Verhoeven et al., 2010). Results of this study showed that children were cognitively engaged in the distraction task, which has reduced the attentional capture by pain. However, cognitive engagement in a distraction task may only be effective in reducing pain when it is related to a more important goal than the processing of pain (Van Damme et al., 2010). It is possible that the distraction task was not the child's prioritized goal and therefore did not gain priority processing over the pain, as a result of which no impact on the pain experience occurred. A challenge for future experimental research may be to develop distraction tasks that are attention-demanding, allow a measurement of engagement (Eccleston, 1995; Piira, Hayes et al., 2002), and also match children's personal goals. The use of such tasks might even be more important for high catastrophizing children, as research has shown that distraction might also be beneficial for high pain catastrophizers when distraction tasks are personally relevant (Verhoeven et al., 2010).

Of additional interest is the finding that the use of distraction in daily life decreases with higher levels of pain catastrophizing. Alternatively, high catastrophizing children seem more likely to use coping strategies that focus attention on the pain, instead of ignoring the pain and directing attention away from pain. This finding is in line with previous research in adults that has shown a positive relationship between pain catastrophizing and a coping style that is directed at trying to solve and control the problem in order to maintain goals (De Vlieger et al., 2006; Eccleston & Crombez, 2007). Instead of using distraction as a first choice in high catastrophizing children, the use of other coping strategies, that are directed at the pain might be considered (e.g., talk about the pain, provide enough information about the pain). An alternative attentional pain coping strategy that might be more useful than distraction in high catastrophizing children, is sensory-focusing, in which attention is focussed on sensory elements of the pain whilst limiting the affective processing of the pain (McCaul & Haugtvedt, 1982; Piira, Hayes, Goodenough, & von Baeyer, 2006; Quartana, Burns, & Lofland, 2007). In adults and students, the use of sensory-focusing techniques holds promising results (Ahles & Blanchard, 1983; Blitz & Dinnerstein, 1971; Leventhal et al., 1979; McCaul & Haugtvedt, 1982), and its use is recommended in high catastrophizing and high anxious individuals (Heyneman et al., 1990; Roelofs, Peters, van der Zijden, & Vlaeyen, 2004). In children, however, research on sensory-focusing techniques is scarce (Piira et al., 2006). Preliminary findings have shown that sensory-focusing can be effective in children. Its applicability, however, may be limited to older children, because younger children might cognitively be unable to make a distinction between the sensory and the emotional aspects of the pain (Piira et al., 2006).

Besides pain catastrophizing, other influencing factors should be taken into account when studying distraction effects. This study suggests that the effectiveness of distraction might also be age dependent. Preliminary findings have shown that distraction might be effective in reducing pain affect in older children, but may increase pain affect in younger children. Future research is however necessary to see whether these results are consistent. It is possible that in order for distraction to be effective, a certain level of cognitive development (i.e., executive functioning) is necessary to fully concentrate on the distraction task, inhibit the pain, and switch back to the distraction task whenever the pain interferes, which might explain the age differences, but this hypothesis has not yet been investigated. The present study suggests that age differences might be situated on the self-reported pain affect component. It is therefore recommended to include (child-rated) pain affect measurements to study distraction effectiveness and possible age differences. Existing studies in this area have mainly focused on pain intensity and tolerance measurements (e.g., Jaaniste et al., 2007; Piira, Taplin et al., 2002) or observer-rated distress measurements (e.g., Berberich & Landman, 2009; Cassidy et al., 2002).

This study may have some clinical implications. Findings show that distraction is not always effective and moderating factors, such as catastrophizing and possibly age, should be taken into account. It is therefore important not to use distraction techniques as a one size fits all strategy, and to keep in mind that one particular distraction technique might not be effective for everyone. While, at worst, distraction might not work for children who are low in pain catastrophizing, for children who are high in pain catastrophizing, distraction might actually increase the pain. In order to improve the effectiveness of distraction in children, further research on influencing factors is necessary to gain more insight in the underlying processes of distraction.

This study has a strong methodological design as it tried to avoid many methodological pitfalls and takes into account many of the previously raised considerations in the field of distraction, including pain measurement, standardisation of the pain induction method, and measurement of distraction task engagement (Eccleston, 1995; Piira, Hayes et al., 2002). Nevertheless, this study has some limitations. First, the results of study 1 are cross-sectional in nature, not allowing conclusions regarding causality. Results of study 1 are also obtained in a retrospective manner, making them susceptible to memory bias. Second, participants of both studies were schoolchildren, not children with chronic pain. Further research is needed to demonstrate whether our results can be replicated in a sample of children experiencing clinically relevant pain. Third, no extreme levels of pain catastrophizing were present in both studies. It might be interesting to replicate our study in a preselected sample of high and low pain catastrophizing children to further explore the role of distraction in high catastrophizing children.

Despite these limitations, this research clearly showed that moderating factors such as catastrophizing, and possibly age, should be taken into account when investigating distraction effectiveness in children. Caution may be warranted when using distraction techniques as a one size fits all strategy, especially in high catastrophizing children.

ACKNOWLEDGEMENTS

The authors thank Sarah Verschuere, Frederik Gevaert, Eva van de Vivere, Sarah Nachtegael, Line Caes and Ake Arnauts for their assistance with the data collection and Pascal Mestdagh for the technical support. Preparation of this paper was partly supported by Grant BOF/GOA2006/001 of Ghent University and FWO project G.017807.

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CHAPTER 5

DISTRACTION FROM PAIN AND EXECUTIVE FUNCTIONING: AN EXPERIMENTAL INVESTIGATION OF THE ROLE OF INHIBITION, TASK SWITCHING AND WORKING MEMORY[1]

ABSTRACT

Although many studies have investigated the effectiveness of distraction as a method of pain control, the cognitive processes by which attentional re-direction is achieved, remain unclear. In this study the role of executive functioning abilities (inhibition, task switching and working memory) in the effectiveness of distraction is investigated. We hypothesized that the effectiveness of distraction in terms of pain reduction would be larger in participants with better executive functioning abilities. Ninety-one undergraduate students first performed executive functioning tasks and subsequently participated in a cold pressor task (CPT). Participants were randomly assigned to (1) a distraction group, in which an attention-demanding tone-detection task was performed during the CPT, or (2) a control group, in which no distraction task was performed. Participants in the distraction group reported significantly less pain during the CPT, but the pain experience was not influenced by executive functioning abilities. However, distraction task performance improved with better inhibition abilities, indicating that inhibition abilities might be important in focussing on a task despite the pain.

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[1] Verhoeven, K., Van Damme, S., Eccleston, C., Van Ryckeghem, D.M.L., Legrain, V., & Crombez, G. (in press). Distraction from pain and executive functioning: An experimental investigation of the role of inhibition, task switching and working memory. *European Journal of Pain* .

INTRODUCTION

The accurate performance of tasks in everyday life requires cognitive monitoring or control (e.g., planning of behaviour, regulation of cognition and emotion, switching between tasks, inhibition of responses), commonly referred to as executive functioning (Funahashi, 2001; Smith & Jonides, 1999). Three important executive functions are often distinguished: Inhibition, task switching and monitoring/updating of memory (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). Because pain can operate to install a priority for attention (Eccleston & Crombez, 1999), it represents a challenge for the smooth-running of everyday behaviour. Executive functions, in particular inhibition, task switching and working memory, may then be important abilities for the successful attentional control of pain.

Distraction is a ubiquitous attentional strategy which is commonly used to control pain. It is characterized by the re-direction of attention away from an aversive experience, and the engagement of attention in other activities (McCaul & Malott, 1984). However, empirical evidence for its effectiveness is equivocal (Van Damme, Legrain, Vogt, & Crombez, 2010), with most studies finding beneficial effects (e.g., James & Hardardottir, 2002; Marchand & Arsenault, 2002), but others finding no effects (e.g., Hodes, Howland, Lightfoot, & Cleeland, 1990; McCaul, Monson, & Maki, 1992) or even counterproductive effects (e.g., Cioffi & Holloway, 1993; Goubert, Crombez, Eccleston, & Devulder, 2004). These heterogeneous findings indicate that distraction is not effective in every situation (Eccleston & Crombez, 1999). Therefore, more insight in the underlying processes of distraction effectiveness is required in order to improve its use.

In order for distraction to be effective, people should be able to engage in the distraction task and inhibit the predominant response of attending to the pain, and resist being interrupted by the pain (Friedman & Miyake, 2004; Nigg, 2000). Distraction is therefore expected to be more effective in people with good inhibition abilities. However, given its fundamentally aversive and interruptive character, it is unlikely that attention to pain can ever be fully inhibited (Eccleston & Crombez, 1999). Moreover, we expect pain to regularly interfere with the engagement in the distraction task (Eccleston, 1995a). Distraction may then be viewed as a process of the dynamic switching of attention between pain and the distraction task (Eccleston & Crombez, 1999). We hypothesize that distraction is more effective for people with good switching abilities (Eccleston, 1995a). Finally, in order for distraction to be effective, one needs to prioritize information in working memory that is relevant for the distraction task (Dalton, Lavie, & Spence, 2009; Dalton, Santangelo, & Spence, 2009; Lavie & de Fockert, 2005). Distraction should therefore be more effective for people with good working memory abilities. In sum, executive functioning abilities, in particular inhibition, task switching and working memory, may influence the effectiveness of distraction, but this hypothesis has not yet been investigated.

In this study, undergraduate students first performed general executive functioning tasks, and subsequently performed a cold pressor task (CPT). Participants were assigned randomly to a distraction group, which performed an attention-demanding tone-detection task during the CPT, or a control group, which performed no distraction task. We hypothesized that distraction would be more effective, in terms of a pain reduction, for participants with better executive functioning abilities.

METHOD

Participants

Ninety-eight undergraduate students from Ghent University (Belgium), who attended prior to any general selection on academic performance, participated in a cold pressor experiment in order to fulfill course requirements (78 females, M_{age}=18.65 years, *SD*=1.28, all Caucasian). Exclusion criteria were Raynaud's disease, a history of epilepsy, frostbite, cardiovascular disease, and any current medical problem of the immersed hand, such as skin lesions, sores or fractures (von Baeyer, Piira, Chambers, Trapanotto, & Zeltzer, 2005). Six participants were excluded (four cardiovascular disease, one epilepsy, and one a recent hand surgery). The remaining participants were randomly (by lottery) assigned to two groups: A distraction group, in which attention to pain during the CPT was manipulated using a distraction task (*N*=43), or a control group, in which no distraction task was performed during the CPT (*N*=49).

Material

Cold pressor task (CPT)

Pain was induced with the cold pressor task (CPT). The cold pressor apparatus consisted of a metallic water container (type Techne B-26 with TE-10D, size 53 x 32 x 17 cm). A circulating water pump (type Techne Dip Cooler RU-200) prevented heat formation around the immersed hand (von Baeyer et al., 2005). The water temperature was kept at 12 °C, and the immersion duration was fixed at 1 minute for each participant (Verhoeven et al., 2010). This way, our self-report measure of pain was not confounded by immersion duration, and each participant experienced the same physical stimulation. The water temperature was considerably higher than other distraction studies (e.g., Cioffi & Holloway, 1993; Johnson & Petrie, 1997; Roelofs, Peters, van der Zijden, & Vlaeyen, 2004), but a recent study on distraction, and additional pilot studies have revealed that this temperature and immersion interval create a painful stimulus of moderate pain intensity, which can be endured by most people, and is ideal to measure distraction effects (Verhoeven et al., 2010). Lower temperatures often provoke high intense pain, which is undesirable for the purpose of this experiment, because distraction is argued to fail for high intense pain (Eccleston & Crombez, 1999).

Another container filled with room temperature water of 21 °C (type Julabo TW20, size 56 x 35 x 32 cm) was used to standardize hand temperature before the immersion in the cold water container (von Baeyer et al., 2005).

Distraction task

The Random Interval Repetition task was used as a distraction task (RIR; Vandierendonck, De Vooght, & Van der Goten, 1998a; 1998b). The RIR-task is a well validated attention-demanding tone-detection task (Vandierendonck et al., 1998a; 1998b), that has been successfully used as a distraction task in previous research (Goubert et al., 2004; Van Damme, Crombez, Van Nieuwenborgh-De wever, & Goubert, 2008; Verhoeven et al., 2010). Participants were instructed to respond quickly (by button press) to tones (tone duration=150 ms; tone pitch=750 Hz) generated by a computer (ASUS L2000). Tones were presented through headphones (Sony MDR-V150) at random stimulus intervals (900 or 1500 ms). Responses were given by means of a button pressing device, held in the participants' right hand. In this study, the total RIR-task duration was 1 minute (tone amount=51). Reaction time (RT), response variation (SD), and errors were used as measures of behavioural task performance. Anticipations (RTs < 100 ms), non-responses, and outliers (RTs > 3 SD above the individual mean) were removed (Goubert et al., 2004; Van Damme et al., 2008; Verhoeven et al., 2010). Errors were calculated by summing the number of anticipations and non-responses.

It has been argued that distraction tasks might only be effective when they are motivationally relevant (Van Damme et al., 2010). Therefore a financial reward was given to enhance the motivation to perform the distraction task (Verhoeven et al., 2010). Participants could win 10 eurocents every time they pressed the button quickly and accurately. If the response was given too late or inaccurately, they could lose 10 eurocents. During the task no feedback of task performance was given to avoid interference with the distraction process. After the experiment, participants received 3, 4 or 5 euro for their task performance. This amount was randomly assigned, and was unrelated to their actual performance.

Executive functioning tasks

Inhibition

Inhibition was assessed with the anti-saccade task, as used by Miyake and colleagues (2000). This task is a modification of the original anti-saccade task (Everling & Fisher, 1998), as it uses manual key presses instead of eye-movements. (Figure 1). Task completion lasted approximately 10 minutes. Each trial started with a white fixation cross that was centrally displayed against a black background in the middle of a 15" computer screen (HP Compaq nc6120) with a variable duration (one of nine presentation times between 1500 ms and 3500 ms with 250 ms intervals). Then, a visual cue (white square, 1.5 x 1.5 cm) was presented on one side of the screen for 225 ms, followed by a target stimulus (white arrow inside an open square, 6.7 x 6.7 cm) on the opposite side for 150 ms before being masked by white cross-hatching. The participants' task was to indicate the direction of the arrow by pressing the corresponding keyboard key (J="left", I="up", L="right"). This task requires participants to inhibit the automatic response of looking at the cue as this hampers the discrimination of the target orientation. Participants received on-screen written instructions. They started with a short practice phase of 18 trials, and subsequently performed 90 experimental trials. Error feedback was given on-screen. Reaction times were computed after removing anticipations (RT < 100ms) and outliers (RT > 3 SD above the individual mean). Mean reaction time served as a measure of inhibition capacity. The higher the reaction times, the lower the inhibition ability.

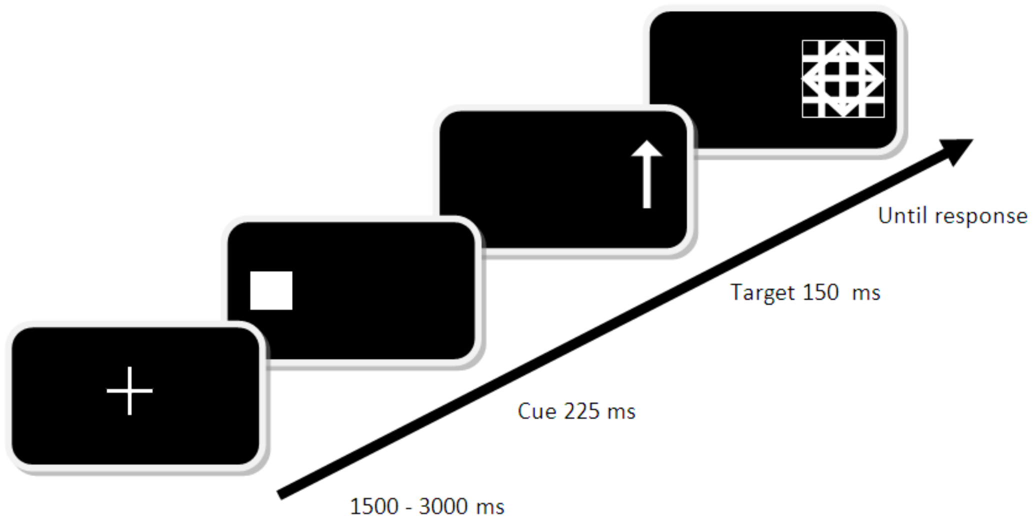

Figure 1: Inhibition task

Task switching

Task switching abilities were assessed with a variant of the task switching paradigm (Meiran, Chorev, & Sapir, 2000) (Figure 2), which is considered to be a reliable measurement of task switching capacities (Vandierendonck, Liefooghe, & Verbruggen, 2010). In this task, which took approximately 20 minutes to perform, participants were instructed to switch as quickly as possible between two randomly presented reaction time computer tasks (50% colour discrimination task, 50% shape discrimination task). Each trial started with the presentation of the word “colour” or “shape” against a black background in the middle of a 15”computer screen for 400 ms (HP Compaq nc6120). After 100 ms, a red or green-coloured and circle or triangle-shaped target stimulus was presented for 500 ms. Participants were instructed to indicate whether the target was green or red, when presented with the cue “colour”, or whether the target was a circle or triangle, when presented with the cue “shape”, by pressing the corresponding keyboard key (F=“green/triangle”, J=“red/circle”). Stimuli remained visible until response, or until the response time had elapsed (4000 ms). The next trial started 1500 ms after the response was given. Trials were categorized as switch trials when the current task differed from the previous task (colour-after-shape-task or shape-after-colour-task), and categorized as repetition trials when the current task was similar to the previous task (colour-after-colour-task or shape-after-shape-task). Normally, it takes more time to perform a switch trial than a repetition trial. Switch cost was calculated by subtracting reaction times on repetition trials from reaction times on switching trials (RT_{switch}-$RT_{repitition}$) (Meiran et al., 2000). RTs were calculated after removing the first trial of each block, as well as error trials, and trials preceded by errors (Meiran et al., 2000), anticipations (RT < 200) and outliers (RT > 3 SD above the individual mean). Participants received on-screen written instructions. The experiment started with a short practice phase of 16 trials, followed by a test phase of 256 experimental trials, which were divided into four blocks. A short break was introduced after each block. In practice trials, error feedback was presented on-screen for 500 ms. Switch cost served as a measure of task switching ability, with higher levels referring to a lower switching ability.

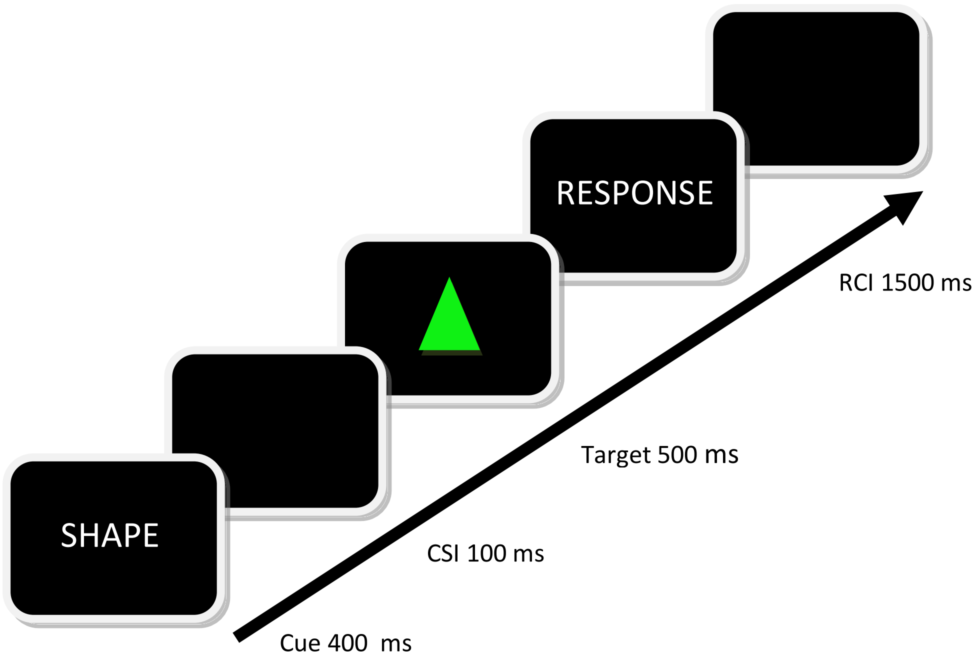

Figure 2: Switching task

Working memory

Working memory was assessed with the "digit span" subscale of the WAIS-III (Wechsler, 2005). This test assesses processes used for temporarily storing and manipulating information. The subscale digit span is reliable and valid for different age groups (Wechsler, 2005). Participants were presented with a sequence of digits which they had to repeat initially in the same (8x2 trials), and afterwards in the reverse direction (7x2 trials). The maximum digit sequence is nine (forward) and eight (backward). Digit sequences started at two digits, and for each trial a digit was added. Participants were given two chances to repeat each sequence length. When they missed both trials, the test was aborted. The total score was calculated by summing the total amount of backward and forward recalled digits. The higher the total score, the better the working memory capacity.

Self-report measures

Sample characteristics

Participants indicated their pain experience prior to the experiment by means of the Graded Chronic Pain Scale (Von Korff, Ormel, Keefe, & Dworkin, 1992). This questionnaire is valid and reliable for several pain problems (Von Korff et al., 1992). The Graded Chronic Pain Scale contains several numerical rating scales (NRS) (0-10) that measure pain intensity (three items, namely pain right now, worst pain and average pain during 6 months), and disability (three items, namely interference with daily activities, social activities and work activities). Total intensity and disability scores vary from 0 to 100. Participants were also asked to register the total number of disability days during the past 6 months (range 0-180), and were classified in grades 0 (“pain free”), 1 (“low disability-low intensity”), 2 (“low disability-high intensity”), 3 (“high disability-low intensity”) and 4 (“high disability-high intensity”).

Self-reported attention to pain

Two items were used to measure self-reported attention to pain. Participants were asked to indicate how much attention they had paid to pain, and the degree to which they were able to distract themselves from pain during the CPT. Both items were scored on a numeric rating scale (NRS) from 0 (“not at all”) to 10 (“very much”). An “attention to pain” score was calculated by subtracting the ability to distract from pain from the amount of attention paid to pain (range -10 to +10). The higher the score, the more attention was paid to pain during the CPT.

Self-reported distraction task experience

Distraction task experience and motivation to perform the task were assessed with six items. Participants in the distraction group were asked to indicate how difficult and interesting the task was, how much attention they paid to the task, and how important it was for them to perform the task well. They were also asked to indicate how much effort they had put in the task. Finally, at the end of the experiment, participants’ beliefs about the effectiveness of the distraction task were assessed. All items were scored on a NRS from 0 to 10 (0=“not at all”; 10=“very much”).

Self-reported pain during the CPT

Pain experience during the CPT was assessed through self-report. A distinction was made between pain intensity and pain affect (Eccleston, 1995b; Leventhal, 1992). Pain intensity was assessed with two items. Participants were asked to indicate (1) the worst pain, and (2) the pain just before the end of the immersion on a NRS from 0 to 10 (0="no pain"; 10="the worst imaginable pain"). According to Kahneman and colleagues (1993), these two measures are valid indicators of the pain experience during the CPT. A total pain intensity score was computed by summing these two pain intensity items (range 0-20). Pain affect was assessed with three items. Participants were asked to indicate (1) how unpleasant the experience was, and (2) how anxious and (3) tense they were during immersion on a 0-10 NRS (0="not anxious/relaxed/pleasant" and 10="very anxious/tense/unpleasant"). A total pain affect score was computed by summing these three pain affect items (range 0-30).

Procedure

Participants received standard information about the experiment when entering the experimenter room. They were told that *"the main interest of the experiment was to examine the effect of an aversive experience on cognitive functioning*". They were instructed to perform several cognitive tasks, and a cold pressor task (CPT). Participants were unaware that the experiment was about distraction effectiveness. After instructions, participants first conducted the general executive functioning tasks, which lasted approximately 35 minutes. Subsequently, they performed the painful cold pressor task, which in total took approximately 10 minutes. Participants received standard information about the CPT. After instructions, they immersed their left hand for 1 minute in the room temperature tank to standardize the hand temperature. Participants were instructed to *"immerse their hand and wrist, not to form a fist and not to move their fingers"* (von Baeyer et al., 2005). Before the cold water immersion, participants in the distraction condition received information about the distraction task. They were instructed to *"perform an auditory task during immersion in the cold pressor tank"* and were told that *"good performance was important"*. Participants were instructed that "*they could win 10 eurocent every time they pressed the button quickly and accurately, and could lose 10 eurocent every time they pressed the button too late or inaccurately.*

They could earn a total of 6 euro, which they would receive at the end of the experiment". Participants in the control group were instructed to *"keep their thoughts on the cold water and on the pain they experienced"* (Leventhal, Brown, Shacham, & Engquist, 1979). After instructions, participants immersed their left hand in the cold water container for 1 minute. Directly following immersion, the pain experience questions were assessed (Koyama, Koyama, Kroncke, & Coghill, 2004). Participants in the distraction group also completed the distraction task engagement questions. The CPT ended with submersion in the room temperature tank to recover (von Baeyer et al., 2005). The experimenter stayed in the room during the whole experiment, and was sitting behind a screen to minimize contact with participants. Participants were collectively debriefed about the study aims after study completion.

RESULTS

One participant of the sample of 92 was removed because of a high number of errors on the distraction task (3 SDs above the group error mean). Statistical analyses were conducted on the remaining 91 participants (72 females, mean age=18.68 years ± 1.30), by using SPSS 15.0. Where relevant, effect sizes were calculated. The criteria of Cohen (1988) were used to determine whether results had a small (0.20), moderate (0.50) or large (0.80) effect.

Descriptive statistics

Sample characteristics

The majority of the sample (97%) reported good health. The minority reported minor medical problems (15%), mostly allergies or occasional back pains. None of the participants experienced psychological problems. Sixty-eight percent of the participants reported having experienced pain during the past 6 months, which was of average intensity (M=47.42, SD=17.50, range 0-100) and mildly disabling (M=33.33, SD=22.94, range 0-100). Participants were classified in pain grades 0 (31.9%), 1 (29.7%), 2 (26.4%), 3 (11%) and 4 (1.1%). Pain grades were equally distributed between the distraction and the control group ($\chi 2(4)$=3.35, p>.10), and were unrelated to the measures of executive functioning (all $F<1.8$, $p>.10$). Furthermore, no differences in age ($t(89)=0.69$, $p>.10$) and sex ($\chi 2(1)=0$, $p>.10$) were found between the two experimental groups.

Executive functioning abilities

Descriptive analyses showed no differences in inhibition ability between the distraction group (M=338 ms, SD=84 ms; 99% correct responses) and the control group (M=346 ms, SD=68 ms; 99% correct responses) ($F(1,88)=0.29$, $p>.10$, $d=0.11$). Also, no differences were found in task switching abilities between the distraction group (M=98 ms, SD=116 ms; 95% correct responses) and the control group (M=68 ms, SD=77 ms; 95% correct responses) ($F(1,86)=2.06$, $p>.10$, $d=0.31$). Finally, no differences were found in working memory abilities between the distraction group ($M=16.35$, $SD=3.37$) and the control group ($M=15.21$, $SD=2.56$) ($F(1,89)=3.34$, $p>.05$, $d=0.38$). No significant correlations between inhibition, task switching and working memory abilities were observed (all $r<.13$, all $p>.10$).

Engagement with the distraction task

Descriptive analyses were conducted on distraction task performance measures and self-reported distraction task experience measures. Results showed that participants performed the distraction task quickly (RT: M=221 ms, SD=57 ms) and accurately (Errors: $M=1.79$, $SD=2.04$), with little variation in response time (SD: M=57 ms, SD=22 ms). Performance measures are comparable with other studies that have used the RIR-task as a distraction task (Van Damme et al., 2008). Furthermore, participants in the distraction group reported paying attention to the distraction task ($M=8.31$, $SD=1.42$). They evaluated the task as moderately interesting ($M=5.29$, $SD=2.48$), found it important to perform the task well ($M=7.02$, $SD=2.04$), and made an effort to do so ($M=6.81$, $SD=2.29$). The task was not rated as difficult ($M=2.69$, $SD=2.28$), and participants believed that the task could work to diminish pain during the CPT ($M=6.78$, $SD=2.12$).

We explored the relationship between distraction task performance measures, the self-reported experience of the distraction task, and the measures of executive functioning by means of Pearson correlations (see Table 1). Results indicated that task performance was significantly related to inhibition abilities. When inhibition abilities were better, reaction times were significantly faster, and response variation was smaller. The amount of errors on the distraction task was also lower, but this correlation failed to reach significance (p=.09). Surprisingly, when switching and working memory abilities were better, performance on the distraction task did not significantly improve. Further analyses showed, that when switching abilities were better, significantly less attention to the distraction task was reported. For working memory, this relationship just failed to reach significance (p=.06).

Overall effects of distraction on attention to pain and pain experience

ANOVA were conducted to examine differences in attention to pain, pain intensity and pain affect between the distraction group and the control group. Results indicated that participants in the distraction group reported less attention to pain (M=-2.67, SD=2.83, min=-8, max=3) than controls (M=3.52, SD=2.92, min=-3, max=9) (F(1,89)=104.78, p<.001, d=2.15), and experienced the pain as less intense (M=9.21, SD=4.40, min=2, max=16) than controls (M=11.17, SD=4.16, min=1, max=18) (F(1,89)=4.76, p<.05, d=0.46). Pain affect did not significantly differ between the distraction (M=14.05, SD=5.23, min=4, max=26) and the control group (M=15.49, SD=5.70, min=1, max=29) (F(1,88)=1.56, p>.10, d=0.26).

Impact of executive functioning on distraction effectiveness

To examine the role of executive functioning (inhibition, task switching and working memory) in the effectiveness of distraction, a series of moderator analyses was conducted (see Table 2). In these analyses, attention to pain, pain intensity and pain affect served as the dependent variables, and inhibition, task switching and working memory served as the moderating variables. Following the procedure of Holmbeck (1997), predictor (group) and moderating variables (inhibition, task switching and working memory) were centred, and entered in a first step. The interaction term of (predictor x moderator) was entered in a second step. The effects of the different moderator variables were examined in separate analyses. Results of these moderator analyses indicated that inhibition, task switching and working memory were not significantly related to attention to pain, pain intensity and pain affect. Contrary to our expectations, inhibition, task switching and working memory did not moderate the relationship between the distraction manipulation and the pain experience[1].

[1] Analyses were repeated by only including participants with average pain intensity scores (≥ 10) to check whether low pain levels might explain the lacking relationship between executive functioning and distraction effectiveness (N=56). However, the same results were found using higher pain ratings, indicating that executive functioning did not influence the pain experience (all $t<1$, $p>.10$), nor the effectiveness of distraction (all $t<1.4$, $p>.10$).

Table 1

Means (M), standard deviations (SD) and Pearson correlations of executive functions, behavioral distraction task (RIR) measures, attention to pain and to the distraction task and pain experience in the distraction group

	M (SD)	1	2	3	4	5	6	7	8	9	10
1. Inhibition	338 (84)	-	.07	-.07	.41**	.37*	.26	-.21	.11	-.08	-.08
2. Task switching	98 (116)		-	-.01	.08	.13	.08	.32*	.03	-.23	-.22
3. Working memory	16.35 (3.37)			-	-.06	.11	-.20	-.29	.18	-.04	.11
4. RIR RT	221 (57)				-	.64**	.13	-.26	.04	-.08	-.19
5. RIR SD	57 (22)					-	.37*	-.09	.21	-.10	-.11
6. RIR Errors	1.79 (2.04)						-	.05	.10	.17	.10
7. Attention to RIR	8.31 (1.42)							-	-.30	-.17	-.14
8. Attention to pain	-2.67 (2.83)								-	.39*	.32*
9. Pain intensity	9.21 (4.40)									-	.62**
10. Pain affect	14.05 (5.23)										-

Note: Reaction times (RT) and response variation (SD) are presented in ms,**p*<.05; ***p*<.01.

Table 2

Hierarchical regression analyses with group, inhibition, task switching and working memory as predictors, and attention to pain, pain intensity and pain affect as criterion variables

Criterion variables	Step	Predictor	β	ΔR^2	Adj. R^2
Attention to pain	**1**	**Group**	-.74**	.54**	.53**
		Inhibition	-.04		
	2	**Inhibition x group**	.10	.01	.53**
	1	**Group**	-.74**	.55**	.54**
		Task switching	-.05		
	2	**Task switching x group**	.07	.004	.54**
	1	**Group**	-.74**	.54**	.53**
		Working memory	-.01		
	2	**Working memory x group**	.11	.01	.54**
Pain intensity	**1**	**Group**	-.25*	.07[a]	.04[a]
		Inhibition	-.09		
	2	**Inhibition x group**	.01	.00	.03
	1	**Group**	-.22*	.09*	.06*
		Task switching	-.15		
	2	**Task switching x group**	-.04	.001	.05[a]
	1	**Group**	-.22*	.05	.03
		Working memory	-.03		
	2	**Working memory x group**	.00	.00	.02
Pain affect	**1**	**Group**	-.15	.03	.01
		Inhibition	-.11		
	2	**Inhibition x group**	.04	.002	-.002
	1	**Group**	-.13	.04	.01
		Task switching	-.10		
	2	**Task switching x group**	-.08	.01	.01
	1	**Group**	-.13	.02	-.01
		Working memory	-.01		
	2	**Working memory x group**	.10	.01	-.01

Note: Standardized betas of the last step are displayed,*p<.05; **p<.001; [a]p=.05.

DISCUSSION

This study investigated the role of executive functioning in the effectiveness of distracting attention away from pain. Participants first performed three tasks of different executive functions (inhibition, task switching and working memory). Subsequently, they performed a painful cold pressor task, during which half of the participants performed an attention-demanding tone-detection task (distraction group), whereas the other half did not (control group). Results can be readily summarized.

Distraction was effective in diminishing pain, but contrary to our expectations, participants with better executive functioning abilities did not report less pain during distraction compared to participants with less executive functioning abilities. However, we did observe that those with better executive functioning abilities performed the distraction task better compared to those with less executive functioning abilities. Results will be more extensively discussed, suggestions for future research formulated, and clinical implications outlined.

This study revealed a small effect of distraction on self-reported pain. This is in line with other studies that have shown beneficial effects of distraction (James & Hardardottir, 2002; Johnson, Breakwell, Douglas, & Humphries, 1998; McCaul & Haugtvedt, 1982; Miron, Duncan, & Bushnell, 1989; Terkelsen, Andersen, MØlgaard, Hansen, & Jensen, 2004). Our study, however, has further value. Participants were kept unaware that this experiment was about the effects of distracting attention away from pain, thereby minimizing the possibility that our distraction effects are merely the result of participants' beliefs in the effectiveness of distraction (Leventhal, 1992). This study also meets many methodological considerations in the field of distraction research (Eccleston, 1995b), including the measurement of pain, the standardisation of the pain induction method, and the measurement of distraction task performance.

Contrary to our expectations, general executive functioning abilities (inhibition, task switching and working memory) did not produce larger pain reduction during distraction, indicating that participants with better executive functioning abilities did not benefit more from distraction than participants with less executive functioning abilities. We also did not find any overall effects of executive functioning on self-reported pain intensity and affect. This is in line with a recent study in adults which examined the relationship between executive functioning and pain experience, but not its effects upon distraction effectiveness (Oosterman, Dijkerman, Kessels, & Scherder, 2010). This study did not find a relationship between the self-reported pain experience, inhibition and working memory. Participants with better inhibition abilities, however, endured cold pressor pain for a longer period of time. It remains unclear how to interpret this finding because pain tolerance was not measured using the standard protocol (i.e., immersion until participants experienced substantial pain).

There is still some debate about the unitariness of the inhibition construct, and there is a growing consensus that inhibition consist of different aspects, namely (1) resistance to distractor interference (i.e., the ability to resist or resolve interference from information in the external environment that is irrelevant), (2) prepotent response inhibition (i.e., the ability to deliberately suppress dominant, automatic and prepotent responses), and (3) resistance to proactive interference (i.e., the ability to resist memory intrusions from information that was previously relevant but has since become irrelevant) (Friedman & Miyake, 2004; Nigg, 2000). It may be useful for future research to measure the different aspects of inhibition using a multi-method approach. This would allow the use of a latent variable analysis (cfr. structural equation modeling), which would probably create greater reliability of the inhibition measurement (Friedman & Miyake, 2004).

Additionally, we explored the role of executive functioning upon the engagement with the distraction task. Results showed that having good inhibition abilities improved the performance on a distracting task despite the presence of pain. This finding suggests that efficient engagement with tasks in the presence of pain may require inhibition. This idea is also supported by fMRI (Bantick et al., 2002) and EEG studies (Legrain, Bruyer, Guérit, & Plaghki, 2005). The dorsal anterior cingulate cortex (ACC) and the dorsolateral prefrontal cortex (DLPC), which are also involved in the attentional control of pain (Tracey & Mantyh, 2007), are generally postulated to play a role in inhibition (Aron, Robbins, & Poldrack, 2004; Dreher & Berman, 2002; Roberts & Wallis, 2000). Results further indicated that task switching did not influence the performance on the distraction task. It may be that task switching abilities are less important than inhibition abilities in performing a distraction task during pain. However, it is also possible that switching between two neutral cognitive tasks is different from switching between the processing of pain and a distraction task. It may be that switching attention away from pain towards a distraction task, also requires the inhibition of predominant responses. A challenge for future research will then be to develop tasks that provide an independent measure of the ability to switch attention away from pain. It may well be that such specific measures would be better predictors of distraction task performance and distraction effectiveness than the switching task here used. Inspiration may be found in recent research on the role of switching in emotion (Johnson, 2009).

Finally, the significant effects of task switching, and marginally significant effects of working memory abilities on self-reported distraction task experience measures were unexpected, and at first sight counter-intuitive. When task switching and working memory abilities were better, participants reported spending less attention to the distraction task. One possible explanation might be that individuals with better task switching and working memory abilities need less effort to obtain equal distraction task performance compared to individuals with less executive functioning abilities, and can therefore simultaneously engage in both the pain and the distraction task. This interpretation is preliminary and awaits further corroboration. This idea might be further tested by using distraction tasks with a variable working memory load (Buhle & Wager, 2010; Forster & Lavie, 2007).

Our findings may have clinical implications. There is now ample evidence that chronic pain patients experience cognitive deficits that are sufficiently important to affect their daily life activities (Dick & Rashiq, 2007; Grisart, Van der Linden, & Masquelier, 2002; Hart, Martelli, & Zasler, 2000; Leavitt & Katz, 2006; Schmitz et al., 2008). Patients' attentional complaints have attracted interest from fundamental neuroscience research (Bantick et al., 2002; Bingel, Rose, Gläscher, & Büchel, 2007; Legrain et al., 2009), and this has led to a renewed interest in the attention management components of standard psychological interventions (Elomaa, Williams, & Kalso, 2009; Morley, Shapiro, & Biggs, 2004). The findings of our study suggest that attention management strategies may be more effective if they attempt to improve patients' ability to maintain attentional focus and inhibit distracting information.

This study has some limitations. First, our sample consisted of undergraduate students, who are relatively homogeneous in terms of age and intelligence (Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001; Rosselli & Ardila, 2003). Replication in other samples with more variability in executive functioning is necessary to allow generalization of our findings. Second, the undergraduate research sample mainly consisted of women, and the number of men was too small to meaningfully examine gender differences. Future research should therefore investigate whether results differ for men. Third, executive functioning is not the only factor that is argued to influence distraction task engagement. Other factors, for instance catastrophic thinking about pain, may also play a role in distraction task engagement (Crombez, Van Damme, &

Eccleston, 2005; Goubert et al., 2004; Van Damme, Crombez, & Eccleston, 2004; Van Damme, Crombez, & Lorenz., 2007). As this study made no attempts to account for other individual differences, results are limited to general effects. Fourth, we found a relationship between distraction task performance (i.e., reaction time and response variation) and inhibition abilities. Because both tasks are reaction time tasks, it is possible that this relationship is stronger than the relationship between distraction task performance and other executive functions measures. However, we also found a marginally significant relationship between the number of errors on the distraction task and inhibition. Future research might consider using other measures of inhibition to further explore this relationship. Finally, pain was induced with the cold pressor test, a well validated pain inducing method (von Baeyer et al., 2005), that is often used in distraction research (e.g., Cioffi & Holloway, 1993; de Wied & Verbaten, 2001; Johnson & Petrie, 1997; McCaul & Haugtvedt, 1982; Van Damme et al., 2008). The CPT, however, has the disadvantage that the pain experience may fluctuate during immersion, with the pain increasing rapidly in the beginning of the immersion, and the pain leveling off after 2 to 4 minutes (Eccleston, 1995b; Handwerker & Kobal, 1993; von Baeyer et al., 2005; Walsh, Schoenfeld, Ramamurthy, & Hoffman, 1989). Therefore we used a fixed immersion paradigm of 1 minute instead of a pain tolerance paradigm to ensure that all participants would experience the same physical stimulation.

In conclusion, this study shows a relationship between executive functioning and distraction task performance, with particular support for the role of inhibition, indicating that distraction task performance improves with better inhibition abilities. How this might influence pain experience remains to be explored.

ACKNOWLEDGMENTS

The authors thank Evelyne Lagrou and Lies Notebaert for programming the executive functioning tasks. Preparation of this paper was partly supported by Grant BOF/GOA2006/001 of Ghent University and FWO project G.017807.

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CHAPTER 6

THE ROLE OF EXECUTIVE FUNCTIONING IN CHILDREN'S ATTENTIONAL PAIN CONTROL: AN EXPERIMENTAL ANALYSIS[1]

ABSTRACT

Directing attention away from pain is often used as a pain management strategy. However, empirical evidence concerning its effectiveness is inconclusive, leading to the idea that attentional control may at best be only partially effective, and may be dependent upon a range of other factors. This study investigates the role of executive functioning as an influencing factor of distraction effectiveness. Schoolchildren (*N*=162) first completed executive functioning tasks, assessing inhibition, task switching and working memory abilities, and subsequently performed a cold pressor task (CPT), in which they immersed their hand for 1 minute in water of 12 °C. Half of the sample simultaneously performed an attention-demanding tone-detection task (distraction group), the other half did not (control group). Results showed that children in the distraction group were indeed engaged in the distraction task, and reported paying significantly less attention to pain than controls. Executive functioning influenced distraction task engagement. In particular, children with good inhibition and working memory abilities performed the distraction task better, and children with good task switching abilities reported paying more attention to the distraction task. Further, distraction was ineffective in reducing pain, and executive functioning did not influence the effectiveness of distraction. However, a relationship was found between executive

[1] Verhoeven, K., Eccleston, C., Goubert, L., Dick, B.D., & Crombez, G. (submitted). The role of executive functioning in children's attentional pain control: An experimental analysis.

functioning and pain affect, indicating that children with good inhibition and working memory abilities overall experienced the CPT as less stressful and less unpleasant.

INTRODUCTION

Distraction is an intuitive way of coping with pain, and is often used in children's pain treatment programs (Leventhal, 1992; Powers, 1999). Several reviews on the effectiveness of distraction in children exist (Chambers, Taddio, Uman, & McMurtry, 2009; DeMore & Cohen, 2005; Kleiber & Harper, 1999; Piira, Hayes, & Goodenough, 2002; Powers, 1999; Uman, Chambers, McGrath, & Kisley, 2008). Although they generally report small positive effects of distraction, results are heterogeneous across different pain outcome measurements, settings, and those delivering the distraction (Chambers et al., 2009; Piira et al., 2002; Uman et al., 2008). Heterogeneous findings may be the result of methodological problems (Eccleston, 1995b; Piira et al., 2002). They may also point to the role of moderating variables (Eccleston & Crombez, 1999; Kleiber & Harper, 1999). This study, in particular, investigates the role of executive functioning as a moderating factor of distraction effectiveness.

Executive functioning is an umbrella term used to describe a variety of cognitive functions that are found to rely primarily on the prefrontal cortex (e.g., goal-shielding, attentional control, problem-solving, self-regulation, organisation) (Homack & Riccio, 2004; Huizinga, Dolan, & van der Molen, 2006; Jurado & Rosselli, 2007). Research has identified three important executive functions: Inhibition (i.e., the ability to inhibit dominant automatic or prepotent responses), task switching (i.e., the ability to shift back and forth between multiple tasks, operations or mental sets) and working memory (i.e., the ability to update and monitor working memory representations) (Fisk & Sharp, 2004; Huizinga et al., 2006; Lehto, Juujärvi, Kooistra, & Pulkkinen, 2004; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). These executive functions share a small common variance, but are generally considered to be unitary constructs (Huizinga et al., 2006; Miyake et al., 2000). This finding is also supported by neuro-imaging studies (Aron, Robbins, & Poldrack, 2004; Crone, Wendelken, Donohue, & Bunge, 2005; Roberts & Wallis, 2000; Rushworth, Walton, Kennerley, & Bannerman, 2004). Executive functioning increases through childhood, with adult performance levels reached after the age of 12, and maturation still possible in adolescence (Cepeda, Kramer, & Gonzales de Sather, 2001; Huizinga et al., 2006).

Recently, the involvement of executive functioning has been hypothesized as critical to the effectiveness of distraction (Legrain et al., 2009; Verhoeven et al., in press). In order for distraction to be effective, people should be able to engage in the distraction task and inhibit the predominant response of attending to the pain, and resist being interrupted by pain (Friedman & Miyake, 2004; Nigg, 2000). It can therefore be expected that distraction is more effective in people with good inhibition abilities. However, given its fundamentally aversive and interruptive character, it is unlikely that attention to pain can ever be fully inhibited (Eccleston & Crombez, 1999). Moreover, it can be expected that pain will regularly interfere with the engagement in the distraction task (Eccleston, 1995a). Distraction may then be viewed as a process of the dynamic switching of attention between pain and the distraction task (Eccleston & Crombez, 1999). It can therefore be hypothesized that distraction is more effective in people with good task switching abilities. Finally, in order for distraction to be effective, one needs to prioritize information in working memory that is relevant for the distraction task (Dalton, Lavie, & Spence, 2009; Dalton, Santangelo, & Spence, 2009; Lavie, & de Fockert, 2005). Distraction should therefore be more effective in people with good working memory abilities. In children, the relationship between distraction and executive functioning, in particular inhibition, task switching and working memory, has not yet been investigated

In this study, schoolchildren first performed general executive functioning tasks, and subsequently performed a cold pressor task (CPT). Participants were randomly assigned to a distraction group, in which an attention-demanding tone-detection task was performed during the CPT, or a control group, in which no distraction task was performed. We hypothesized that children with better executive functioning abilities would benefit more from distraction. Additionally, we explored the relationship between executive functioning and distraction task engagement, expecting a larger task engagement in children with greater executive functioning abilities.

METHOD

Participants

A total of 239 schoolchildren (9-19 years) from nine elementary and high schools in Ghent (Belgium) were invited to participate in a cold pressor experiment. Children were randomly recruited (by means of a computerized program) from a sample of 1015 schoolchildren, who participated in a large questionnaire study on pain experience in children, and consented to be re-contacted for experimental research. Forty-eight declined to participate, mainly because of lack of time or interest. Eleven of them met one of the exclusion criteria, namely Raynaud's disease, previous experience with the cold pressor task (*N*=2), heart conditions, cuts and sores on the hand to be immersed, chronic pain (*N*=3), epilepsy, developmental disorders (autism and ADHD) (N=2), color blindness (*N*=3), dyslexia (*N*=1) or poor comprehension of the Dutch language. Of the 180 children who agreed to participate, 174 actually did (response rate 97%)[2]. The main reason given for not participating was "lack of time". All children were Belgian (98% Caucasian), and reported good health and psychological functioning. The minority of the sample reported minor medical problems (20%) - in most cases allergies and asthma. Seventy-four percent of the children's parents were married or cohabiting. Seventy percent of the mothers, and 65% of the fathers were educated (beyond the age of 18 years).

Children and parents participated voluntarily and received reimbursement to cover transport costs (25-35 euro). Both provided a written informed consent, and were fully debriefed after the experiment. The experiment was approved by the ethical committee of the Faculty of Psychology and Educational Sciences of Ghent University.

Material and measures

Sample characteristics

An ad hoc questionnaire was used to assess socio-demographic sample characteristics of children (e.g., sex, age) and parents (e.g., education level, current

[2] Half of the sample consisted of the children who participated in the experimental study in chapter 4 (part 2). For the purpose of this particular study, the sample size was doubled.

profession, family situation). Psychological and physical health of the child was also included (open questions).

Children's pain characteristics were assessed with six items that are based on the Varni-Thompson Pediatric Pain Questionnaire (PPQ; Varni, Thompson, & Hanson, 1987). Children were asked to indicate whether they experienced pain during the past two weeks. If this question was answered affirmative, children were then asked to indicate all pain locations on a manikin figure. Overall pain intensity (0="a little bit" to 3="very much") and frequency (0="once" to 3="all the time") were also assessed. Finally, children indicated the present pain and the worst pain they experienced during the last two weeks on a visual analogue scale (VAS) (0="no pain"; 100="very much pain").

Cold pressor task (CPT)

Children participated in a pain-inducing cold pressor task (CPT), which is often used in children's pain research (von Baeyer, Piira, Chambers, Trapanotto, & Zeltzer, 2005). The cold pressor apparatus consisted of a metallic water container (type Techne B-26 with TE-10D, size 53 x 32 x 17cm). A circulating water pump (type Techne Dip Cooler RU-200) prevented heat formation around the immersed hand (von Baeyer et al., 2005). We used a fixed immersion paradigm (i.e., immersion for a certain period of time), in which children immersed their hand for 1 minute, instead of a tolerance paradigm (i.e., immersion until the pain can no longer be tolerated), which is less useful in experiments with children with a broad age range, because younger children tend to endure the cold pressor task for a shorter period of time than older children (Jaaniste, Hayes, & von Baeyer, 2007), and the pain experience may be confounded by the immersion duration (Eccleston, 1995b). By using a fixed immersion interval, each child experienced the same physical stimulation. The water temperature was kept constant at 12 °C. Previous research has revealed that this temperature and the 1 minute immersion duration creates a painful stimulus of moderate pain intensity, and is suitable for investigating distraction effects (Verhoeven et al., 2010). A highly intense pain stimulus was considered undesirable in this experiment, because distraction is argued to fail for high intense pain (Eccleston & Crombez, 1999).

To standardize the hand temperature before the immersion in the cold water bath, another container filled with water of room temperature was used (21 °C) (type Julabo TW20, size 56 x 35 x 32cm) (von Baeyer et al., 2005).

Distraction task

The distraction task used was the Random Interval Repetition task (RIR; Vandierendonck, De Vooght, & Van der Goten, 1998a; 1998b). The RIR-task is a well validated tone-detection task of which research has shown that it is highly attention-demanding (Vandierendonck et al., 1998a; 1998b). This task has been successfully used as a distraction task in previous research (Goubert, Crombez, Eccleston, & Devulder, 2004; Van Damme, Crombez, Van Nieuwenborgh-De wever, & Goubert, 2008; Verhoeven et al., 2010). Children were instructed to respond as quickly as possible to tones (tone duration=150 ms; tone pitch=750 Hz) generated by a computer (ASUS L2000). Responses were given by means of a button pressing device, held in the right hand. In this experiment, we used an adaptation of the original RIR-task. In the original task, tones are presented at stimulus-stimulus interval, with a randomly chosen inter stimulus interval of 900 or 1500 ms. Younger children, however, may need more time to respond to the tones compared to older children, leaving them with less time to prepare cognitively for the next tone. Therefore, we presented the tones at response-stimulus interval (i.e., the next tone is presented at a random stimulus interval of 900 or 1500 ms after responding to the previous one). By giving everyone an equal amount of time to prepare for the next tone, we made the task equally difficult for children of all ages. Tones were presented through headphones (Sony MDR-V150). In this study, the total RIR-task duration was 1 minute.

It has been argued that distraction tasks may only work when they are motivationally relevant (Van Damme, Legrain, Vogt, & Crombez, 2010). Therefore, a financial reward was given to enhance the motivation to perform the distraction task (see Verhoeven et al., 2010). Financial rewards are considered to be very influential and are often used to increase motivation in experimental research in adults and children (Bonner & Sprinkle, 2002; Kohls, Peltzer, Herpertz-Dahlmann, & Konrad, 2009). Research has shown that the interest in and the understanding of money rapidly increases between the ages of 5 and 7, and is fully established at the age of 8 (Berti & Bombi, 1981; Grunberg & Anthony, 1980). In this study, participants could win 10 eurocents every time they pressed the button quickly and accurately. If the response was given too late or inaccurately, they could lose 10 eurocents. After the experiment, participants received 3, 4 or 5 euro for their task performance. This amount was randomly assigned and was unrelated to the actual task performance.

Distraction task engagement

Task performance served as a behavioural measurement of distraction task engagement. We calculated children's reaction time (RT) and response variation (SD), excluding anticipations (RTs < 100 ms), non-responses and outliers (RTs > 3 SD above the individual mean) (Goubert et al., 2004; Van Damme et. al., 2008; Verhoeven et al., 2010). Errors were calculated by summing the number of anticipations and non-responses.

Self-reported distraction task engagement was examined with two items. Children in the distraction group were asked to indicate how much "attention they paid to the task" and how "important it was for them to perform the task well". All items were scored on a 0 to 100 mm VAS, labelled at 0 mm ("not at all"), 25 mm ("a little bit"), 50 mm ("quite a bit"), 75 mm ("a lot") and 100 mm ("very much").

Self-reported attention to pain

Attention to pain was assessed with two items. Children were asked to indicate on a 100 mm VAS how much attention they paid to the pain, and the degree to which they were able to distract from the pain during the CPT. The scale was labelled at 0 mm ("not at all"), 25 mm ("a little bit"), 50 mm ("quite a bit"), 75 mm ("a lot") and 100 mm ("very much"). An "attention to pain" score (range -100 to +100) was calculated by subtracting the ability to distract from pain from the amount of attention paid to pain. The higher the score, the more attention was paid to pain during the CPT.

Self-reported pain during cold pressor task (CPT)

Pain experience during the CPT was assessed through self-report. Pain intensity was assessed with two items. Children were asked to indicate the worst pain and the pain just before the end of the immersion on a 100 mm VAS, labeled at 0 mm ("no pain”), 25 mm (“low pain”), 50 mm (“moderate pain”), 75 mm (“most intense pain”) and 100 mm (“enormous pain”). These two measures have proven to be valid indicators of the pain experience during the CPT (Kahneman, Fredrickson, Schreiber, & Redelmeier, 1993). A total pain intensity score was calculated by adding the two pain intensity items (range 0-200). Pain affect was assessed with two items. Children were asked to indicate how unpleasant the cold pressor experience was and how anxious/tense they were during immersion on a 100 mm VAS from -50 (“relaxed/pleasant”) to +50 (“very anxious/unpleasant”). A total pain affect score was calculated by adding the two pain affect items (range -100 to +100).

Executive functioning

Inhibition

Inhibition is argued to be comprised of different components, namely (1) prepotent response inhibition (i.e., the ability to deliberately suppress dominant, automatic and prepotent responses), (2) resistance to distractor interference (i.e., the ability to resist or resolve interference from information in the external environment that is irrelevant), and (3) resistance to proactive interference (i.e., the ability to resist memory intrusions from information that was previously relevant but has since become irrelevant). Response inhibition and resistance to distractor inhibition are related, but resistance to proactive interference is not (Friedman & Miyake, 2004). It can be expected that prepotent response inhibition (“response inhibition”) and resistance to distractor intereference inhibition (“interference inhibition”) are related to the attentional control of pain.

Response inhibition was assessed with the anti-saccade task, as used by Miyake et al. (2000). This task is a modification of the original anti-saccade task (Everling & Fisher, 1998), as it uses manual key presses instead of eye-movements.Task completion took approximately 10 minutes. Each trial started with a white fixation cross that was presented against a black background in the middle of the computer screen (HP Compaq nc6120, 15 inch) with a variable duration (one of nine presentation times between 1500 ms and 3500 ms in 250 ms intervals). Then, a visual cue (white square, 1.5 x 1.5 cm) was presented on one side of the screen for 225 ms, followed by a target stimulus (arrow inside an open square, 6.7 x 6.7 cm) on the opposite side for 150 ms before being masked by white cross-hatching. Participants were asked to indicate the direction of the arrow by pressing the corresponding keyboard key (J="left", I="up", L="right"). This task requires participants to inhibit the automatic response of looking at the cue because this hampers the identification of the direction of the target. Children were tested individually and received on-screen written instructions. They started with a short practice phase of 18 trials and subsequently performed 90 experimental trials. Error feedback was given on-screen. Reaction times were computed after removing anticipations (RT < 100ms) and outliers (RT > 3 SD above the individual mean) (Verhoeven et al., 2010). Reaction times served as the dependent variable. Lower reaction times refer to better inhibition abilities.

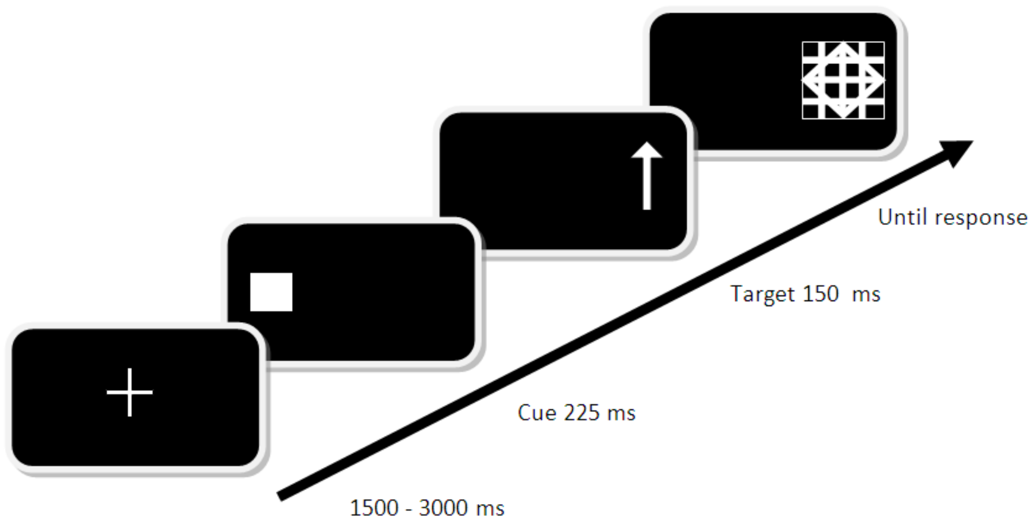

Figure 1: Inhibition task

Interference inhibition was assessed with the Stroop colour-word test (Stroop, 1935). Research has indicated that the Stroop colour-word test is reliable (Homack & Riccio, 2004). This test consists of three cards, each displaying 100 stimuli arranged in five columns of 20 items each. The first card ("words") displays colour names (blue, green, red and yellow) written in black ink. Children were instructed to read the words as fast as possible. The second card ("colour") displays colour bars (blue, green, red and yellow). Children were instructed to identify the colour as fast as possible. The third card ("interference") displays colour words (blue, green, red and yellow), which are printed in a conflicting colour. Children were required to identify the ink colour and inhibit the automatic tendency to read the word. For each card, the total reading time as well as the amount of errors were calculated. An interference score was calculated by subtracting the total time to read the second card from the third card. This score provided an inhibition measure and served as the dependent variable. Lower interference scores, reflect better inhibition abilities.

Task switching

Task switching abilities were assessed with a variant of the task switching paradigm developed by Meiran, Chorev and Sapir (2000) (see Figure 2). The task switching paradigm is often used to measure task switching ability (Crone, Bunge, van der Molen, & Ridderinkhof, 2006; Vandierendonck, Liefooghe, & Verbruggen, 2010). The task here used takes about 7 minutes to perform. Children were instructed to switch as quickly as possible between two randomly presented reaction time computer tasks (50% colour identification task, 50% shape identification task). Each trial started with the presentation of the cue “colour/shape” on a computer screen (HP Compaq nc6120, 15 inch) for 400 ms. After a cue-stimulus interval of 100 ms, a target (blue or yellow triangle or circle) was presented for 500 ms. Children were instructed to indicate whether the target was blue or yellow, when presented with the cue “colour”, or whether the target was a circle or triangle, when presented with the cue “shape” by pressing the corresponding keyboard key (F=“yellow/triangle”, J=“blue/circle”). Stimuli remained visible until response, or until response time had elapsed (4000 ms). The response-stimulus interval was 1500 ms. Children performed a switch trial when the current task differed from the task on the previous trial (colour/shape task or shape/colour task), and a repetition trial when the current task was similar to the task on the previous trial (colour/colour task or shape/shape task). Normally, it takes more time to perform a switch trial than a repetition trial, creating a switch cost (Meiran et al., 2000). Reaction times were calculated after removing the first trial of each block as well as error trials and trials preceded by errors (Meiran et al., 2000). Anticipations (RT < 200) as well as outliers (RT > 3 SD above the individual mean) were removed. Children were tested individually, and received on-screen written instructions. The experiment started with a short practice phase of 16 trials, that was followed by a test phase of 128 experimental trials, which were divided in two blocks. A short break was introduced after the first block. Only in practice trials error feedback was presented on-screen for 500 ms. Switch cost was calculated by subtracting reaction times on repetition trials from reaction times on switching trials (RT_{switch} - $RT_{repitition}$) and served as a measure of task switching ability. The higher the switch cost, the lower the task switching ability.

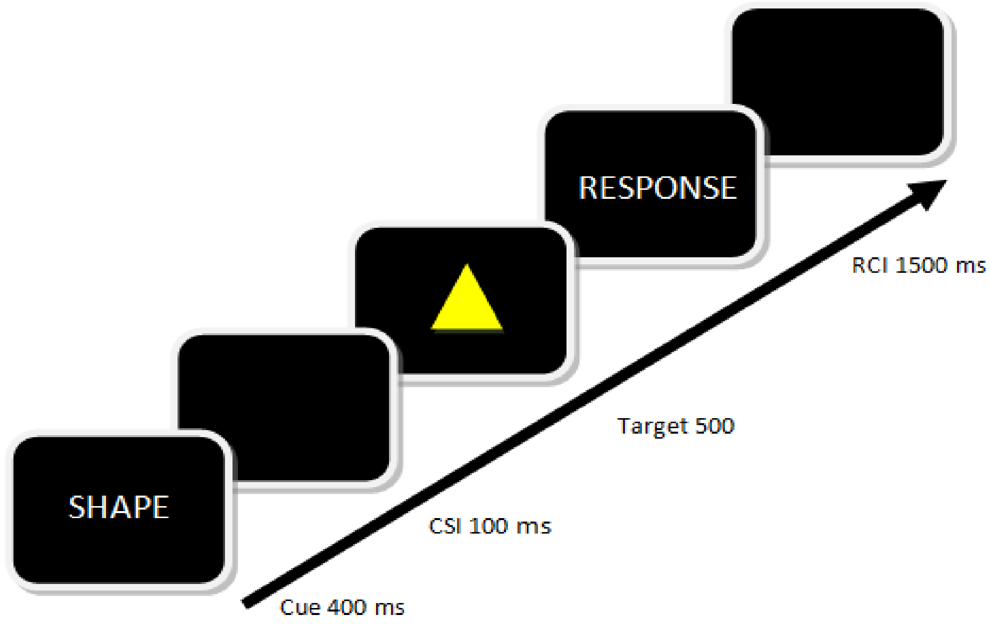

Figure 2: Switching task

Working memory

Working memory was assessed with the "digit span" subscale of the Dutch version of the third edition of the Wechsler Intelligence Scale for Children (WISC-III NL). Research has shown that the WISC-III is reliable and valid (Evers, Van Vliet-Mulder, & Groot, 2000; Kort et al., 2005). Children were presented with a sequence of numbers which they were instructed to repeat initially in the same (8x2 trials), and subsequently in the reverse direction (7x2 trials). The maximum sequence is nine (forward) and eight (backward). Number sequence started at two numbers. For each trial a number was added. Children were given two chances to repeat each sequence length. When they missed both trials, the test was aborted. A total WISC-III score for working memory capacity was calculated by summing backwards and forward scores, and served as dependent variable. The higher the score, the better the working memory capacity.

Experimental manipulation

Children were randomly assigned to a distraction group, in which attention to pain during the CPT was manipulated using a distraction task (N=85, 45 girls, M_{age}=13.80, SD=2.58), or a control group, in which no distraction task was performed (N=89, 43 girls, M_{age}=13.69, SD=2.68).

Procedure

Children were randomly selected from a population of schoolchildren (N=1015). Parents were contacted by phone and received standardized information about the experiment. They were informed that their child would be asked to perform a cold pressor test, in which they should try to immerse their hand in cold water for 1 minute. They were told that their child would be asked to perform several other tasks, which would then be related to the child's pain experience. Parents were informed that their child could stop the experiment at all times, and were told that they would receive a reimbursement to cover transport costs. When parents agreed to participate, exclusion criteria were discussed. When their child did not meet any of the exclusion criteria, an appointment was made. Parents received a confirmation to participate, and a transportation map by mail.

Upon arrival, parents and the participating child received information about the experiment, and provided informed consent. Children were told that "*they would be asked to complete several questionnaires, perform several tasks, namely a colour task* (Stroop)*, two computer tasks* (anti-saccade task and switching task)*, a memory task* (digit span task)*, and a cold pressor task (CPT), in which they should try to immerse the left hand in cold water for 1 minute.* They were informed that *"the cold pressor task, is generally experienced as unpleasant and painful, and is safe and often used in pain research"*. Children were told that the aim of the experiment was to investigate "pain experience", and were unaware that the experiment examined distraction from cold pressor pain. That way, potential placebo effects were kept at a minimum (Benedetti, 2006; Vase, Riley, & Price, 2002). Parents were seated in a waiting room where they completed the socio-demographic questionnaire, and were offered the possibility to participate in another study, which was of no relevance for the current study. The child completed the questionnaires, performed the executive functioning tasks and the cold pressor task in the adjacent room.

After performing the executive functioning tasks - which took approximately 30 minutes - the children received standard information about the cold pressor procedure, and immersed their left hand for 1 minute in the room temperature tank to standardize hand temperature (von Baeyer et al., 2005). Before the cold water immersion, children in the distraction group received information about the distraction task. They were instructed to *"focus on the task during immersion"* and were informed that *"it was important to perform the task well".* They were instructed that they *"could earn 10 eurocent every time they pressed the button fast and accurately, and lose 10 eurocent every time they pressed the button too late or inaccurately, with the possibility to earn a maximum of 6 euro, which they would receive at the end of the experiment".* Children in the control group were instructed to *"keep their mind on the cold water and the pain they experienced"* (Leventhal, Brown, Shacham, & Engquist, 1979). Finally, children in both groups were instructed to *"immerse their hand and wrist, not to form a fist and not to move their fingers*" (von Baeyer et al., 2005). After instructions, children immersed their left hand in the cold water container for 1 minute. Immediately following the cold water immersion, they answered questions about the pain experience (Koyama, Koyama, Kroncke, & Coghill, 2004). Children in the distraction group also completed the distraction task questions. The cold pressor procedure ended with hand submersion for 1 minute in the room temperature tank to recover (von Baeyer et al., 2005). During the cold pressor task, the researcher stayed in the room and was seated behind a screen to minimize contact with the child. After the cold pressor task, parents and child were reunited and fully debriefed.

Data analysis

Twelve children were removed from the sample: Five participants did not endure the cold pressor task for 1 minute (control group: N=4, two girls, M_{age} =11.00 years, SD=0.82 years; distraction group: N=1 girl, 12 years), one participant made too many errors on the distraction task (3 SDs above the group error mean), two participants (both in the distraction group) did not experience pain during the CPT, one participant reported having severe chronic pain despite previous screening, and three participants' trials were subject to technical problems. Statistical analyses were conducted on the remaining 162 children (control group: N=84, 40 girls, M_{age}=13.80, SD=2.68; distraction group: N=78, 42 girls, M_{age}=13.95, SD=2.55) by using SPSS 15.0. Effect sizes were calculated by using Cohen's *d* (0.20 "small", 0.50 "medium" or 0.80 "large" effects) (Cohen, 1988).

First, descriptive analyses were used to investigate distraction task engagement, and its relationship with executive functioning abilities. Second, we examined overall differences in attention to pain, pain intensity, and pain affect between the distraction and control group by means of ANOVA analyses. Third, we examined the role of executive functioning in the effectiveness of distraction with a series of moderator analyses (Holmbeck, 1997). In these analyses, attention to pain, pain intensity and pain affect served as the dependent variables. In the first step, we controlled for age and sex. Group allocation and executive functioning measurements were included in the second step. In the third step, we entered the interaction terms of group with executive functioning measurements. All variables were centered (Aiken & West, 1991).

RESULTS

Descriptive statistics

Sample characteristics

The majority of the sample experienced pain during the two weeks prior to the study (77%), which was mostly described as low (30%) or moderately intense (58%). Leg pain (42%), stomach ache (18%), and pain in other parts of the body (e.g., hands, feet) (33%) were the most frequently reported. The majority of the sample reported having experienced pain once (24%), or a few times (61%) during the past two weeks. At the moment of testing, 48% reported being pain free, the other half reported some type of pain (also pain from bumps and bruises), which was of low intensity (M=15.20, SD=16.39, range 0-100). The distraction and control group did not differ in terms of current experienced pain ($t(160)=1.01$, $p>.10$, $d=0.16$), age ($t(160)=-0.37$, $p>.10$, $d=0.06$), and sex ($\chi^2(1)=0.63$, $p>.10$).

Executive functioning abilities

Descriptive analyses were conducted on executive functioning measurements. Pearson correlations showed a significant relationship between interference inhibition and response inhibition ($r=.25$, $p<.01$), indicating that, as previously discussed, constructs conceptually overlap, but generally measure different constructs of inhibition. Interference inhibition was related to working memory ($r=-.23$, $p<.01$). All other executive functioning measurements were not interrelated (all $r<.15$, $p>.05$).

Furthermore, Pearson correlations showed an association between executive functioning abilities and age, indicating that with higher age, response inhibition ($r=-.39$, $p<.001$), interference inhibition ($r=-.50$, $p<.001$) and working memory abilities ($r=.28$, $p<.001$) improved. For task switching, this relationship failed to reach significance ($r=-.14$, $p=.07$). Independent sample *t*-tests showed no overall differences in executive functioning between boys and girls (all $t<1.83$, $p>.05$, $d<0.30$).

Finally, independent sample *t*-tests showed no differences between the distraction group and the control group in response inhibition ($M_{contr}=443$ ms, $SD=130$; $M_{distrac}=435$ ms, $SD=127$), interference inhibition ($M_{contr}=31.27$, $SD=14.55$; $M_{distrac}=31.44$, $SD=15.75$), task switching ability ($M_{contr}=226$ ms, $SD=188$; $M_{distrac}=219$ ms, $SD=186$), and working memory abilities ($M_{contr}=15.10$, $SD=3.36$; $M_{distrac}=14.85$, $SD=3.43$) (all $t<1$, $p>.10$, $d<0.08$).

Distraction task engagement

Descriptive analyses were conducted on distraction task performance measures (RT, SD and errors), and self-reported distraction task engagement measures (attention to task, importance to perform). Results showed that children in the distraction group performed the distraction task quickly (RT: $M=254$ ms, $SD=69$ ms) and accurately (Errors: $M=2.5\%$, $SD=3\%$), with little variation in response time (SD: $M=69$ ms, $SD=30$ ms). Furthermore, children, on average, reported to have paid much attention to the task ($M=77$, $SD=25$). They found it moderately important to perform the task well ($M=57$, $SD=24$).

Pearson correlations showed a relationship between distraction task performance, self-reported distraction task engagement, and executive functioning measurements (see Table 1). More specifically, distraction task performance was related to both response and interference inhibition, indicating that distraction task performance improved with better inhibition abilities. Task performance was also related to working memory, indicating that with better working memory abilities the number of errors made on the distraction task decreased (r=-.38, p<.01). Self-reported distraction task engagement was associated with task switching abilities, indicating that with better task switching abilities more attention to the distraction task was reported (r=-.26, p<.05).

Overall effects of distraction on attention to pain, pain intensity and pain affect

ANOVAs were conducted to examine overall differences in attention to pain, pain intensity and pain affect between the distraction group and the control group. Results indicated that children in the distraction group reported significantly less attention to pain (M=-34, SD=36, min=-100, max=25) than controls (M=23, SD=38, min=-69, max=100) (F(1,160)=96.17, p<.001, d=1.54), indicating that our distraction manipulation was indeed successful. However, no overall differences were found in pain intensity (M_{contr}=96, SD=47, min=17, max =200; M_{distr}=89, SD=46, min=5, max= 200) and pain affect (M_{contr}=9, SD=42, min=-100, max=90; M_{distr}=9, SD=36, min=-85, max=85) between the distraction and the control group (all F<1, p>.10, d<0.16).

Table 1

Means (M), standard deviations (SD) and Pearson correlations of executive functions, distraction task (RIR) performance measures, attention to pain and to the distraction task and pain experience in the distraction group

	M (SD)	1	2	3	4	5	6	7	8	9	10	11
1. Response inhibition	435 (127)	-	.10	.21	-.10	.22 [(a)]	.28*	-.003	.06	-.004	.14	.15
2. Interference inhibition	31.44 (15.75)		-	-.09	-.24*	-.02	.31**	.32**	-.01	-.13	.09	-.18
3. Task switching	219 (186)			-	-.14	.08	.01	-.02	-.26*	.18	-.07	.03
4. Working memory	14.85 (3.43)				-	.04	-.17	-.38**	.16	-.19	-.04	-.14
5. RIR RT	254 (69)					-	.58**	-.22 [(a)]	-.001	.05	.11	.09
6. RIR SD	69 (30)						-	.13	-.23*	.19	.11	.18
7. RIR Errors	1.28 (1.60)							-	-.15	-.01	.02	-.01
8. Attention to RIR	77 (25)								-	-.46**	-.12	-.27*
9. Attention to pain	-34 (36)									-	.17	.42**
10. Pain intensity	89 (46)										-	.55**
11. Pain affect	9 (36)											-

Note: Reaction times (RT) are presented in ms, self-report measurements in mm, [(a)]$p<.06$; *$p<.05$; *$p<.01$.

Impact of executive functioning on distraction effectiveness

To examine the impact of influencing factors on the effectiveness of distraction, a series of moderator analyses was performed with attention to pain, pain intensity and pain affect as the dependent variables, and group allocation and executive functioning abilities as the independent variables. We also controlled for age and sex. Results showed no main effects of executive functioning on attention to pain (all $t<1.5$, $p>.10$) (see Table 2). We did find an interaction-effect of (group x working memory) on attention to pain ($t=-2.16$, $p<.05$), indicating that with better working memory abilities, more attention was paid to pain in the control group, and less attention was paid to pain in the distraction group. Furthermore, results showed no main effects of executive functioning, or interaction-effects of (group x executive functioning) on pain intensity (all $t<1.4$, $p>.10$). Finally, results showed main effects of working memory ($t=-2.31$, $p<.05$) and response inhibition ($t=1.99$, $p<.05$) on pain affect, indicating that with better working memory abilities and inhibition abilities, pain affect decreased during the cold pressor task. No interaction-effects of (group x executive functioning) were found on pain affect (all $t<1.11$, $p>.10$).

Table 2

Hierarchical regression analyses with group, inhibition, task switching and working memory capacity as predictors and attention to pain, pain intensity and pain affect as criterion variables

Criterion variables	Step	Predictor	β	ΔR²	Adj R²
Attention to pain	**1**	**Age**	.04	.01	.001
		Sex	.11		
	2	**Group**	-.61***	.40***	.39***
		Response inhibition	-.03		
		Interference inhibition	-.12		
		Task switching	.05		
		Working memory	-.01		
	3	**Group x Response inhibition**	-.01	.02	.39***
		Group x Interference inhibition	.03		
		Group x Task switching	.04		
		Group x Working memory	-.14*		
Pain intensity	**1**	**Age**	-.03	.01	-.001
		Sex	.04		
	2	**Group**	-.08	.03	-.003
		Response inhibition	.13		
		Interference inhibition	.06		
		Task switching	-.09		
		Working memory	-.001		
	3	**Group x Response inhibition**	.003	.00	-.03
		Group x Interference inhibition	.01		
		Group x Task switching	-.01		
		Group x Working memory	.01		
Pain affect	**1**	**Age**	.20(a)	.03	.02
		Sex	.12		
	2	**Group**	.002	.06	.04(a)
		Response inhibition	.17*		
		Interference inhibition	-.01		
		Task switching	.07		
		Working memory	-.19*		
	3	**Group x Response inhibition**	.01	.02	.04
		Group x Interference inhibition	-.06		
		Group x Task switching	-.09		
		Group x Working memory	.06		

Note: Standardized betas of the last step are displayed, (a)*p*=.05; **p*< 05; ***p*<.01;****p*<.001.

DISCUSSION

This study investigated the role of executive functioning as a moderating factor of distraction effectiveness in children. Children first completed executive functioning tasks, assessing inhibition, task switching and working memory abilities, and subsequently performed a painful cold pressor task (CPT). Half of them simultaneously performed an attention-demanding tone-detection task (distraction group), the other half did not (control group). Results can be readily summarized. The distraction manipulation was successful, with children in the distraction group reporting significantly less attention to pain than controls. However, distraction was found to be ineffective in reducing pain intensity and pain affect during the CPT. Executive functioning was associated with the engagement in the distraction task, but did not moderate the effectiveness of distraction.

Although children in the distraction group were engaged in the distraction task, and reported having paid less attention to pain than controls, distraction was found to be ineffective in reducing pain intensity and pain affect during the cold pressor task. This finding contradicts other studies in children that have found beneficial effects of distraction (Kleiber & Harper, 1990; Uman et al., 2008; Vessey, Carlson, & McGill, 1994), but is in line with other studies in children that also did not find effects of distraction (Arts et al., 1994; Carlson, Broome, & Vessey, 2000; Cassidy et al., 2002; Jaaniste et al, 2007; Manne, Redd, Jacobsen, Gorfinkle, & Schorr, 1990). Heterogeneous findings may point to the role of moderating factors. One possible moderating factor is executive functioning. It can be expected that distraction is more effective in children with better inhibition, task switching and working memory abilities, because they should be more able to inhibit attention to pain, to resist being interrupted by pain, to switch attention back to the distraction task whenever the pain interferes, and to remain focused on a distracting task during pain. This study, however, showed that executive functioning did not moderate the effectiveness of distraction, indicating that children with better executive functioning abilities did not benefit more from distraction than children with lower executive functioning abilities. These findings seem to indicate that cognitive abilities are not the most important factor in the effectiveness of distraction. Other individual factors (e.g., pain related affect, preferred coping style, temperament, self-efficacy) may be more important in the effectiveness of distraction, and may also explain why distraction did not impact the pain experience in this study (Kleiber & Harper, 1999; Piira et al., 2002; Piira, Hayes, Goodenough, & von Baeyer, 2006; Verhoeven et al., 2010).

Executive functioning was related to the engagement with the distraction task. More precisely, our results indicated that the performance on a distraction task during pain improved with increasing inhibition and working memory abilities, and self-reported attention to this task increased with increasing task switching abilities. Moreover, this study indicated that both response and interference inhibition are involved in the engagement with a distracting task during pain. Both inhibition abilities were found to be distinct, as they were only mildly correlated - a finding that is in line with previous research (Friedman & Miyake, 2004), and influenced different aspects of distraction task performance. Therefore, we recommend for future research to include different measurements of inhibition, assessing these different aspects.

Of additional interest is the finding that executive functioning was related to the overall experience of pain. Results indicated that children with good inhibition and working memory abilities overall experienced the CPT as less stressful and less unpleasant. This implies that executive functioning abilities might be involved in the overall experience of pain. This hypothesis finds support in neuroimaging studies. For instance, the dorsal anterior cingulate cortex (ACC), and the dorsolateral prefrontal cortex (DLPC), which are considered important underlying structures of executive functioning (Jurado & Roselli, 2007; Miller & Cohen, 2001), are also involved in the attentional control of pain (Apkarian, Bushnell, Treede, & Zubieta, 2005; Tracy & Mantyh, 2007). Other support may be found in a recent behavioral study, which showed a relationship between inhibition and pain tolerance (Oosterman, Dijkerman, Kessels, & Scherder, 2010). The relationship with pain intensity and affect failed to reach significance. Future research is necessary to further explore the relationship between executive functioning and the experience of pain.

Our findings may have clinical implications, as they suggest that individuals with better executive functioning abilities are more able to engage in activities despite the pain. This may in turn prevent them from worse outcomes (Hasenbring, Marienfeld, Kuhlendahl, & Soyka, 1994). There is no direct support for this hypothesis, but indirect support is provided by the finding that adult chronic pain patients often suffer from deficits in executive functioning abilities (Dick & Rashiq, 2007; Grisart, Van der Linden, & Masquelier, 2002; Hart, Martelli, & Zasler, 2000; Leavitt & Katz, 2006; Schmitz et al., 2008). Whether this is also true for children with chronic pain remains to be investigated. Pain treatment programs could consider improving patients' executive functioning abilities, for instance by using mindfulness techniques (Chambers, Chuen Yee Lo, & Allan, 2008). Not only might this help to remain active despite the pain, but it may also influence the experience of pain.

This study has a strong methodological design as it has taken into account the most common methodological problems raised in distraction research (see Eccleston, 1995b for a review; Piira et al., 2002). For instance, we used a stimulus of moderate pain intensity to optimize the chance of finding a standard distraction effect before testing our hypothesis about the modulation of distraction effectiveness by executive functioning abilities (Eccleston & Crombez, 1999). Also, we assessed pain after, instead of during the CPT, to avoid interference with the distraction process, and used different items to measure pain intensity and affect. Further, the use of the cold pressor test was standardized in terms of instructions, immersion duration and exclusion criteria (von Baeyer et al., 2005). We also used a control group, which we instructed in order to avoid the use of spontaneous distraction techniques, and concealed the true purpose of the study to control for bias from participants' beliefs in the putative effectiveness of distraction (Leventhal, 1992). Finally, we used a distraction task that had all the necessary qualities to be effective in reducing pain as it was attention-demanding (Vandierendonck et al., 1998a; 1998b), directed attention to an external cue (Johnson, Breakwell, Douglas, & Humphries, 1998), involved another perceptual modality (Villemure & Bushnell, 2002), was made motivationally relevant (Van Damme et al., 2010), and has been proven successful in previous research (Goubert et al., 2004; Van Damme et al., 2008; Verhoeven et al., 2010). We also investigated the engagement with the distraction task (Eccleston, 1995b). Despite these strengths, there were some limitations. First, participants in this study were generally healthy schoolchildren and the painful stimulation was created and delivered in the laboratory. Further research is needed to demonstrate whether our results can be replicated in a sample of children experiencing clinically relevant pain. Second, executive functioning is not the only factor that is argued to influence distraction effectiveness. Other factors, such as catastrophic thinking about pain, may also influence distraction effectiveness (Goubert et al., 2004; Heyneman, Fremouw, Gano, Kirkland, & Heiden, 1990; Verhoeven et al., 2010). This study made no attempts to account for other individual differences, results are therefore limited to general effects. Third, pain was induced with the cold pressor task (CPT), a well validated pain inducing method, that is often used in distraction research in children (von Baeyer et al., 2005). The CPT, however, has the disadvantage that the pain experience may fluctuate during immersion, with the pain increasing rapidly in the beginning of the immersion, and the pain leveling off after 2 to 4 minutes (Eccleston, 1995b; Handwerker, & Kobal, 1993; von Baeyer et al., 2005; Walsh, Schoenfeld, Ramamurthy, & Hoffman, 1989). Therefore, we used a fixed immersion paradigm of 1 minute instead of a pain tolerance paradigm to ensure that all children would experience the same physical stimulation and our self-report measure of pain was not confounded by immersion duration.

Despite these limitations, the present study clearly showed an association between executive functioning and the engagement with a concurrent task during pain. Executive functioning may also be involved in the overall experience of pain, but further research is necessary to replicate these preliminary findings.

ACKNOWLEDGEMENTS

The autors thank Sarah Verschuere, Frederik Gevaert, Eva van de Vivere, Sarah Nachtegael, and Ake Arnauts for their help with the data input, Pascal Mestdagh for the technical support and Dimitri Van Ryckeghem and Lies Notebaert for their help with the data analysis. Preparation of this paper was partly supported by Grant BOF/GOA2006/001 of Ghent University.

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GENERAL DISCUSSION

This general discussion starts with an overview and discussion of the main study findings. Subsequently, implications for distraction theory, clinical practice and experimental research are outlined. Finally, limitations and avenues for future research are discussed.

REVIEW RESEARCH FINDINGS

Distraction beliefs

In **CHAPTER I**, we explored beliefs about the effectiveness of distraction in university students (**study 1**) and schoolchildren (**study 2**), and investigated whether characteristics of the pain situation and individual differences in pain catastrophizing would influence these beliefs. In **study 2** we also explored beliefs about the effectiveness of sensory-focusing, an attentional coping strategy in which attention is focused on the sensory elements of the pain thereby limiting its affective processing. Results showed that distraction is believed to be moderately effective in reducing pain (**study 1** and **2**), and is believed to be more effective than sensory-focusing (**study 2**), which is considered to be an ineffective coping strategy regardless of the pain situation. Results hereby confirm the existence of a common-sense distraction belief in students (Ahles & Blanchard, 1983; Leventhal, 1992), and extend the existence of such a belief to a population of schoolchildren. However, distraction beliefs were not as strong as was predicted. For instance, distraction is believed to be more effective for others than for themselves. This finding was even more pronounced in high catastrophizing individuals (**study 1**). Results also indicated that distraction beliefs are not general in nature, but instead depend upon characteristics of the pain situation. For instance, students and schoolchildren believed distraction to be less effective in highly threatening pain situations (**study 1** and **2**). Students also believed distraction to be less effective in highly intense pain situations (**study 1**). Distraction beliefs were independent of the novelty of the pain situation (**study 1** and **2**).

There are strong theoretical arguments for distraction being less effective in highly intense, threatening and novel pain situations, as pain automatically attracts attention in these situations (Eccleston & Crombez, 1999; Legrain et al., 2009). However, empirical research examining the effectiveness of distraction in these situations is scarce. The finding that people believe distraction to be less effective in highly threatening and highly intense pain situations provides indirect support for this hypothesis, as beliefs are often the result of personal experiences (Leventhal, Brown, Shacham, & Engquist, 1979; Leventhal, Meyer, & Nerenz, 1980). Pain novelty did not influence distraction beliefs, which might indicate that people also use distraction in novel pain situations. It is possible that the novelty of the pain situation only hinders the effectiveness of distraction in the beginning of the painful experience. As a result, pain novelty might be more easily overruled by top-down factors than the intensity of the pain or the threatening nature of the pain, making this factor less important in the effectiveness of distraction. A recent study indicated that the attentional capture of novel pain stimuli can indeed be overruled by performing a pain-unrelated task which involves working memory (Legrain, Crombez, Verhoeven, & Mouraux, 2011). However, more research is necessary to further explore the relationship between distraction effectiveness and pain characteristics.

Results may have implications for clinical practice. From a theoretical point of view, distraction is expected to be less effective in highly threatening and intense pain situations (Eccleston & Crombez, 1999; Legrain et al., 2009; Van Damme, Legrain, Vogt, & Crombez, 2010), and people also believe distraction to be less effective in these situations. It can therefore be recommended not to use distraction as a first choice in highly threatening pain situations, or to decrease the threat value first, before using distraction. For instance, by providing information about the painful procedure, or by familiarizing the patient with the medical setting (Jaaniste, Hayes, & von Bayer, 2007a; 2007b). It can also be recommended not to use distraction as a first choice in highly intense pain situations, or to decrease the intensity of the pain first, before using distraction. For instance by using medication. An example can be found in the context of wound dressing in burn care. This is a very painful procedure where medication is used, and distraction is often employed as an additional intervention for decreasing the residual pain (de Jong, Middelkoop, Faber, & Van Loey, 2007). Finally, results have shown that distraction is not always believed to be effective. When using distraction in clinical practice, it can therefore be recommended to emphasize the effectiveness of this strategy in order to increase patients‘ distraction beliefs and optimize its effects. This might even be more important in intense and threatening pain situations, as distraction is believed to be less effective in these situations, and in high pain catastrophizing individuals, as their beliefs about the effectiveness of distraction might be lower. Finally, it can also be recommended to emphasize the effectiveness of sensory-focusing when using this technique in clinical practice, as beliefs about the effectivess of this technique appear to be very low, which might hinder the actual effectiveness of this technique.

Results may also have implications for experimental distraction research. Distraction beliefs may confound study results (Leventhal, 1992). For instance, beliefs may influence distraction task engagement, as believers may show a larger motivation to engage in a distraction task than non-believers. Beliefs may also influence the pain experience. It has clearly been shown in the placebo literature that expectancy about the effectiveness of a pain reducing method can reduce the pain experience (de Jong, van Baast, Arntz, & Merchelbach, 1996; Sauro & Greenberg, 2005; Seminowicz, 2006). It is therefore reasonable to assume that distraction beliefs as such may impact the pain experience. In order to avoid confounding influences of distraction beliefs it can therefore be recommended to routinely conceal the true purpose of the experiment. If participants are not aware that they are participating in an experiment about distracting attention away from pain, possible confounding influences of distraction beliefs can be minimized (Leventhal, 1992). On the other hand, when participants do know that they are participating in a distraction experiment, it can be recommended to check, and control for participants’ distraction beliefs.

Pain catastrophizing

In **CHAPTERS 3** and **4** we examined the relationship between distraction and pain catastrophizing in university students (**study 5**) and schoolchildren (**study 6** and **7**). We hypothesized that distraction would be less effective in high catastrophizing individuals, because they are hypervigilant to pain related stimuli, and have more difficulty disengaging attention from pain (Crombez, Eccleston, Baeyens, & Eelen, 1998a; 1998b; Quartana, Campbell, & Edwards, 2009; Seminowicz & Davis, 2006; Van Damme, Crombez, & Eccleston, 2004), which in turn could make it more difficult for them to engage in a distraction task during pain and distract from pain (Goubert, Crombez, Eccleston, & Devulder, 2004; Van Damme, Crombez, Van Nieuwenborgh-De wever, & Goubert, 2008). Indirect support for this hypothesis is provided by the finding that high catastrophizing individuals report using less distraction strategies in daily life, and believe that distraction is more effective for others than for themselves (**study 1**). Direct support is provided by the experimental studies, which showed that distraction is less effective in high catastrophizing students (**study 5**) and schoolchildren (**study 7**). These results hereby replicate the results of previous research in students (Heyneman, Fremouw, Gano, Kirkland, & Heiden, 1990), healthy adults (Campbell et al., 2010) and adult pain patients (Goubert et al., 2004; Spanos, Radtke-Bodorik, Ferguson, & Jones, 1979), and extend results to a population of schoolchildren.

It is possible that distraction is less effective for high pain catastrophizing individuals because it is more difficult for them to engage in a distraction task during pain. However, we did not find a relationship between distraction task engagement and pain catastrophizing (**study 5** and **7**). It is however possible that a relationship between catastrophizing and distraction task engagement will appear when a more difficult distraction task is used than the RIR-task. In the current series of studies, RIR-task engagement measures indicated that high catastrophizing individuals were cognitively engaged in the distraction task. However, it has been argued that cognitive engagement in a distraction task may only impact the pain experience when it is related to a more important goal than the processing of pain (Van Damme et al., 2010). It is reasonable to assume that performing a distraction task during pain is not the focal goal of high pain catastrophizing individuals, but pain processing is. When high catastrophizing individuals comply with the instruction to pay attention to the distraction task, they cannot focus on their focal goal, which might create frustration, and in turn might even increase the pain experience, which was observed in **study 7**. Based on these findings, it can be hypothesized that when the distraction task becomes the focal goal instead of the processing of pain, distraction might also be effective in reducing pain in high catastrophizing individuals. Preliminary support for this hypothesis was found in **study 5**, where the motivation to perform a distraction task was increased, and a decrease in pain intensity in high pain catastrophizers was found. This finding, however, is preliminary and awaits corroboration in future research.

Results may have clinical implications. It may be recommended not to use distraction as a first choice in high pain catastrophizing individuals. Other strategies, in which attention is focussed on the pain, such as providing information about the pain, talking about the pain, or using sensory-focusing , are perhaps more effective strategies for high catastrophizing individuals (Hadjistavropoulos, Hadjistavropoulos, & Quine, 2000; Roelofs, Peters, van der Zijden, & Vlaeyen, 2004; Van Damme, Crombez, & Eccleston, 2002). Nevertheless, when distraction is used in high catastrophizing individuals, it can be recommended to use a distraction task that is related to an important personal goal, as important goals automatically capture attention which might overrule the attentional capture by pain. It can also be recommended to decrease the level of pain catastrophizing before using distraction. Research on pain catastrophizing has shown that although some people are consistent catastrophizers across situations, the level of pain catastrophizing of others might be situation dependent (Ellis & D'Eon, 2002). This implicates that catastrophizing is not necessarily a stable construct and might be reduced to some extent, for instance by using cognitive-behaviour therapy (Jensen, Turner, & Romano, 2001; 2007; Quartana et al., 2009). Finally, highly threatening and intense pain situations may increase pain catastrophizing (Van Damme et al., 2008). This may be an additional argument for not using distraction as a first choice in these situations.

Results may also have implications for experimental research. Pain catastrophizing seems an important factor in the effectiveness of distraction. It can therefore be recommended for future distraction research to routinely control for pain catastrophizing. Future distraction research should always include a measurement of pain catastrophizing, for instance the Pain Catastrophizing Scale (Sullivan, Bishop, & Pivik, 1995) or the Coping Strategies Questionnaire (Rosentiel & Keefe, 1983).

Executive functioning

In **CHAPTERS 5** and **6** the role of executive functioning as an influencing factor of distraction effectiveness was examined in students (**study 8**) and schoolchildren (**study 9**). It was hypothesized that distraction would be more effective in terms of pain reduction in individuals with good inhibition, task switching and working memory abilities, as they should be more able to (1) engage in the distraction task and inhibit the predominant response of attending to the pain and resist being interrupted by pain, (2) switch attention back to the distraction task whenever the pain interferes, and (3) prioritize information in working memory that is relevant for the distraction task (Dalton, Lavie, & Spence, 2009a; Dalton, Santangelo, & Spence, 2009b; Eccleston, 1995a; Friedman & Miyake, 2004; Lavie & de Fockert, 2005; Nigg, 2000).

Across studies, we consistently found a relationship between executive functioning and distraction task engagement, with the strongest support for the role of inhibition. In **study 8**, we found a relationship between response inhibition and the performance on a distraction task in students, indicating that distraction task performance increased with increasing inhibition abilities. In **study 9**, we generalized results to a sample of schoolchildren, and extended results to the role of interference inhibition. This finding suggests that efficient engagement with tasks in the presence of pain probably requires inhibition. This idea is also supported by fMRI (Bantick et al., 2002) and EEG studies (Legrain, Bruyer, Guérit, & Plaghki, 2005). The dorsal anterior cingulate cortex (ACC) and the dorsolateral prefrontal cortex (DLPC), which are also involved in the attentional control of pain (Tracey & Mantyh, 2007), are generally postulated to play a role in inhibition (Aron, Robbins, & Poldrack, 2004; Dreher & Berman, 2002; Roberts & Wallis, 2000). Further research, however, is necessary to replicate findings.

Besides inhibition, other executive functions were also related to distraction task engagement, but results were varied across studies. In **study 8**, no relationship was found between working memory and distraction task enagegement, whereas in **study 9** a relationship was found, indicating that with better working memory abilities the amount of distraction task errors decreased. This finding is in line with other reseach that has shown that working memory abilities are important in the prioritization of information relevant for ongoing tasks (Dalton, Lavie et al., 2009a; Dalton, Santangelo et al., 2009b; de Fockert, Rees, Frith, & Lavie, 2001; Forster & Lavie, 2007). It is possible that the detection of working memory effects was easier in a sample of schoolchildren (**study 9**) with a broader range in executive functioning, than in a sample of students (**study 8**). Finally, a relationship was found between task switching ability and the attention paid to the distraction task, but this relationship was surprisingly reversed in the two studies. In schoolchildren, more attention was reported to the distraction task with better task switching abilities (**study 9**). In students, however, less attention was reported to the distraction task with better task switching abilities (**study 8**). As yet, we do not have a full explanation for these results. It is possible that other factors determine the precise role of task switching in the attentional control of pain. For instance, cognitive factors may play a role in the relationship between task switching and distraction task engagement. Students who are older and more mature in terms of executive functioning than schoolchildren, may perhaps need less effort to engage in the relatively easy RIR-task during pain. Students with good task switching abilities may then be able to pay attention to the distraction task and the pain at the same time, resulting in a lower self-reported attention to the distraction task. When a more difficult distraction task is used, it is possible that the same positive relationship between task switching and attention to the distraction task that was found in schoolchildren, will also occur in students. The relationship between task switching and distraction task engagement, might not only be influenced by cognitive factors, but motivational factors may also play a role. These factors may determine how task switching abilities will be employed. For instance, if one is instructed to pay attention to the distraction task, but prioritizes attending to the pain over performing the distraction task, good task switching abilities may be employed to perform the distraction task and switch attention to the pain at the same time. On the other hand, if one prioritizes distraction task performance over the processing of pain, good task switching abilities can be employed to rapidly switch attention back to the distraction task whenever the pain interferes. In conclusion, the precise role of task switching in the engagement with the distraction task is not yet clear, and other factors such as motivation and cognition might influence the relationship between task switching and distraction task engagement. This hypothesis, however, needs to be addressed in future research.

Contrary to our expectations, students (**study 8**) and schoolchildren (**study 9**) with better executive functioning abilities did not benefit more from distraction in terms of a pain reduction. It is possible that the relationship between the pain experience and executive functioning may be influenced by other factors, such as motivation. For instance, if the motivation to perform the distraction task is larger than the motivation to attend to the pain, good executive functioning abilities may be employed for distraction task performance, with a cognitive and motivational engagement in the distraction task as a result, which in turn is likely to result in a pain reduction. If the motivation to perform the distraction task is lower than the motivation to attend to the pain, good executive functioning abilities may be employed to perform the distraction task and pay attention to the pain at the same time, which may still result in a cognitive engagement with the distraction task, but will most likely not result in a reduction in pain. When executive functioning is low, distraction will most likely be ineffective in reducing pain, because bottom-up characteristics of the pain may hinder the engagement with the distraction task. However, if the motivation to perform the distraction task is high, distraction task engagement may to some point be maintained by increasing attentional effort (Eysenck, Derakshan, Santos, & Calvo, 2007; Sarter, Gehring, & Kozak, 2006; Taylor et al., 2004). It may therefore be premature to conclude that executive functioning does not play a role in the effectiveness of distraction, especially because a relationship between executive functioning and distraction task engagement was found. It is reasonable to assume that other factors determine the precise relationship between distraction effectiveness and executive functioning abilities. It may therefore be recommended to further examine the role of executive functioning in distraction effectiveness, and to pay attention to influencing factors, such as motivation.

Additionally, we explored the relationship between executive functioning and the overall pain experience. We consistently found no relationship between pain intensity and executive functioning (**study 8** and **9**). The relationship between executive functioning and pain affect varied across studies. In **study 8**, we did not find a relationship between pain affect and executive functioning, whereas in **study 9**, however, a relationship was found, indicating that when inhibition and working memory abilities were better, the cold pressor task was experienced as less unpleasant and stressing. Differences between studies might be explained by the different samples used. The sample of schoolchildren (**study 9**) was larger, and more heterogeneous in terms of age and executive functioning than the student sample (**study 8**), which might have facilitated the detection of executive functioning effects. Differences between studies may also have been the result of differences in the assessment of pain affect. In

study 9, pain affect was assessed with other items and another type of scale than in **study 8**. Findings indicated that executive functioning abilities may be involved in the overall experience of pain. This hypothesis finds support in neuroimaging studies. For instance, the dorsal anterior cingulate cortex (ACC) and the dorsolateral prefrontal cortex (DLPC), which are considered important underlying structures of executive functioning (Jurado & Rosselli, 2007; Miller & Cohen, 2001), are also involved in the attentional control of pain (Apkarian, Bushnell, Treede, & Zubieta, 2005; Tracy & Mantyh, 2007). Other support may be found in a recent behavioral study (Oosterman, Dijkerman, Kessels, & Scherder, 2010), which showed a relationship between inhibition and pain tolerance. The relationship with pain intensity and pain affect just failed to reach significance. Future research is necessary to further explore the relationship between executive functioning and the experience of pain.

Findings may have clinical implications. Results of **study 8** and **9** suggest that individuals with better executive functioning abilities, in particular better inhibition abilities, are more able to engage in activities despite the pain. This may is turn prevent them from worse outcomes (Hasenbring, Marienfeld, Kuhlendahl, & Soyka, 1994). There is no direct support for this hypothesis, but indirect support is provided by the finding that chronic pain patients often show a decrease in daily activities, and often suffer from deficits in executive functioning abilities (Dick & Rashiq, 2007; Grisart, Van der Linden, & Masquelier, 2002; Hart, Martelli, & Zasler, 2000; Leavitt & Katz, 2006; Schmitz et al., 2008). Good executive functioning abilities may then be a protective factor in the development of chronic pain problems, but this hypothesis is speculative and needs to be investigated in future research. Pain treatment programs could consider improving patients' optimal use of executive functioning abilities, for instance by using mindfulness techniques (Chambers, Chuen Yee Lo, & Allan, 2008). Not only might this help to remain active despite the pain, but it may also influence the experience of pain. Further, distraction is often found to be ineffective in chronic pain patients, and its use is not recommended in these patients (Eccleston, 1995a; Goubert et al., 2004; Snijders, Ramsey, Koerselman, & van Gijn, 2010). Distraction ineffectiveness might be the result of chronic pain patients' lower executive functioning abilities, which might hinder the optimal use of these abilities for distraction task performance. However, distraction might be effective in chronic pain patients, when a distraction task is used that relates to an important goal, because this may facilitate the optimal employment of executive functions for distraction task performance (Eysenck et al., 2007; Sarter et al., 2006; Taylor et al., 2004). However, this hypothesis needs to be investigated in future research.

Findings may also have implications for experimental research. For instance, results of **study 9** indicated that response and interference inhibition are distinct abilities, hereby supporting previous research (Friedman & Miyake, 2004). It may therefore be recommended for future research to include different measurements of inhibition, assessing these different aspects. Further, in the current series of studies, executive functioning was examined with general executive functioning measurements. It may be interesting to further explore the relationship between executive functioning and pain, by examining executive functioning during pain. For example, by developing tasks which measure executive functioning during pain.

IMPLICATIONS FOR DISTRACTION THEORY

Cognitive or cognitive-motivational models of attention?

The current series of studies have shown that cognitive engagement in a distraction task does not necessarily impact the pain experience. Together with the finding that executive functioning abilities as such were not related to the effectiveness of distraction, this seems to indicate that cognitive models of attention (e.g., limited capacity models) are insufficient in explaining distraction effectiveness. It is possible that cognitive engagement in a distraction task may only impact the pain experience when it is related to an important goal (Van Damme et al., 2010). Cognitive-motivational theories of distraction (Eccleston & Crombez, 1999; Legrain et al., 2009; Van Damme et al., 2010), which are discussed in detail in the introduction of this dissertation, may then be more promising in explaining the effectiveness of distraction, and may appear more useful for future research than cognitive models. According to these cognitive-motivational models, the attentional capture of pain, and therefore the effectiveness of distraction, is influenced by the dynamic interplay between bottom-up characteristics of the pain (e.g., pain intensity, pain novelty and pain threat), and top-down factors (e.g., goal pursuit). Based on these models it can be expected that distraction is less effective in highly intense, threatening and novel pain situations, because pain automatically attracts attention in these situations. It can also be expected that distraction is more effective when the distraction task becomes prioritized over the processing of pain, because important goals automatically attract attention, which may overrule the attentional capture by pain. Motivationally relevant distraction tasks may therefore be more effective in reducing pain, because they are more likely to get prioritized over the processing of pain.

Several findings of this dissertation provide support for these cognitive-motivational models. For instance, the distraction paradigm that was applied in the current series of studies was not always effective in terms of pain reduction. This finding can be explained from a goal-directed perspective. In order to increase the possibility of the distraction task becoming prioritized over the processing of pain, we used a financial reward to increase the motivation to perform the distraction task. Prioritized goals automatically attract attention, while other information is inhibited (Van Damme et al., 2010). However, which goal is prioritized may differ between and within persons, depending upon the situation (Van Damme et al., 2010). It is possible that the distraction task was not always the prioritized goal, and therefore did not always impact the pain experience.

Further, results of the current series of studies indicated that distraction is found to be ineffective in high catastrophizing individuals, and might even intensify the pain experience. However, preliminary results have also indicated that distraction can be effective in high pain catastrophizing individuals when the motivation to perform the distraction task is increased. Increasing the motivation might have several consequences, which may all account for these effects. First, it is possible that attending to the pain is an important goal for high pain catastrophizing individuals. A distraction task that is related to an important goal may then be needed to overcome high pain catastrophizer's tendency to attend to the pain. For low pain catastrophizing individuals, attending to the pain is probably a less important goal, making it relatively easy for any distraction task to become prioritized over the processing of pain. Increasing the motivation to perform a distraction task may then increase the probability of a distraction task becoming prioritized over pain, especially in high pain catastrophizing individuals. Future research might investigate whether high pain catastrophizers indeed pursue different goals during pain than low pain catastrophizers. Second, research has shown that anxiety decreases executive functioning (Eysenck et al., 2007). It is therefore reasonable to assume that high pain catastrophizers' executive functioning capacity during pain is decreased, which could hinder the optimal employment of executive functioning for distraction task performance. It is possible that high pain catastrophizers' executive functioning capacity is temporarily decreased because they are worrying about the pain. However, it is also possible that high catastrophizing individuals have a general deficit in executive functioning. Increasing the motivation to perform the distraction task may then be needed to optimize the employment of executive functions for distraction task performance (Pessoa, 2009; Sarter et al., 2006; Szatkowska, Bogorodzki, Wolak, Marchewka, & Szeszkowski, 2008). Future research might investigate whether high pain catastrophizing individuals indeed have lower executive functioning capacity during pain, and whether this is the result of a temporal decrease in executive functioning, or the result of a general deficit in executive functioning. Secondary analyses of the data of **study 8** and **9**, tend to refute the last assumption. In **study 8**, no correlation (Pearson) was found between pain catastrophizing, inhibition (r=.08, p>.10), task switching (r=.16, p>.10) and working memory (r=.01, p>.10). In **study 9**, no correlation (Pearson) was found between pain catastrophizing, response inhibition (r=-.002, p>.10), interference inhibition (r=.09, p>.10), task switching (r=.04, p>.10) and working memory (r=-.12, p>.10). Further research is, however, necessary to replicate these findings, and to further explore the relationship between pain catastrophizing and executive functioning.

Further, this dissertation has found no support for the role of executive functioning in the effectiveness of distraction in terms of a pain reduction. It is however premature to conclude that executive functioning does not play a role in the effectiveness of distraction, especially because a relationship was found between executive functioning and distraction task engagement. It is more likely that the relationship between executive functioning and distraction is influenced by other factors, such as the motivation to perform a distraction task. Motivation may influence the amount of executive functions that is employed for performing the distraction task and is used to prevent the attentional interference by pain. Investigating the relationship between executive functioning and motivation may be an interesting avenue for further distraction research.

Finally, cognitive-motivational models predict that distraction is less effective in highly threatening, intense and novel pain situations. This dissertation provides indirect support for this hypothesis. First, participants believed that distraction is less effective in highly threatening and intense pain situations (**study 1** and **2**). As beliefs are often the result of personal experiences, this might indicate that they have also experienced that distraction is less effective in these situations (Leventhal et al., 1979; Leventhal et al., 1980). Second, the water temperature of the CPT had to be increased several times before finding distraction effects (**study 3**, **4** and **5**), which might indicate that distraction is less effective in more intense pain situations. Finally, distraction was found to be less effective in participants who experienced the pain as threatening (i.e., catastrophize about pain) (**study 5** and **7**). As a result, it can therefore be recommended not to use distraction as a first choice in highly intense and threatening pain situations. Pain novelty may also impact the effectiveness of distraction. In all studies, the CPT was performed only once, without previous experience with the cold pressor stimulation, which might have hindered the effectiveness of distraction. However, it is possible that the novelty of the pain situation only hinders the effectiveness of distraction in the very beginning of the painful experience. After a while, the pain becomes more familiar, and top-down factors may easily overrule the bottom-up effect of the novelty of the pain.

Extending cognitive-motivational models of attention

Findings of the current series of studies provide support for the usefulness of cognitive-motivational models in distraction theory and research. Results can also be used to extend these models by incorporating executive functioning, pain catastrophizing and beliefs.

According to this extended model, the role of goal-pursuit is expected to be a very important top-down factor in the effectiveness of distraction. Two scenarios appear apparent. When people are instructed to perform a distraction task during pain, they (1) may prioritize distraction task performance over the processing of pain, or (2) they may prioritize the processing of pain over distraction task performance – the latter might be more prevalent in high pain catastrophizing individuals and perhaps also in chronic pain patients. When the distraction task is prioritized, information that is important for pursuing this goal will automatically attract attention, and executive functions will be employed to protect this goal from irrelevant distracters. This may result in the cognitive, as well as the motivational engagement in the distraction task, with pain reduction as a result. On the other hand, when pain processing is the prioritized goal, executive functioning abilities may be employed to perform the distraction task and pay attention to the pain at the same time. This may result in the cognitive engagement in the distraction task, but not in a reduction in pain. In conclusion, goal-pursuit may determine how executive functions are employed for the pursuit of important goals. However, the amount of executive functions that can be employed for the pursuit of important goals, may differ between people (e.g., high versus low executive functioning abilities or high versus low pain catastrophizers) and situations (e.g., influence of bottom-up characteristics of the pain). For instance, when executive functioning abilities are good, and the distraction task is the prioritized goal, executive functions will be used for distraction task performance. Distraction task engagement will be large, and distraction will most likely result in a reduction in pain. However, when the distraction task is not the prioritized goal, good executive functions may be employed to perform the distraction task and pay attention to the pain at the same time. Distraction may then be ineffective in people with good executive functioning abilities. On the other hand, when executive functioning abilities are low, bottom-up characteristics of the pain may hinder the engagement with the distraction task, resulting in the ineffectiveness of distraction. However, when the distraction task is an important goal, lower executive functioning can, to some point, be compensated by increasing effort (Eysenck et al., 2007; Sarter, Gehring, & Kozak, 2006; Taylor et al., 2004). This way the employment of executive functioning abilities for distraction task performance can be optimized and distraction may be effective in individuals with lower executive functioning abilities (e.g., high pain catastrophizing individuals, chronic pain patients). In conclusion, the precise role of executive functioning in distraction effectiveness may probably depend upon the interaction between cognitive factors and motivational factors.

Whether pain processing or distraction task performance is prioritized differs between and within people, depending upon the situation. Expectancy-valence theories of motivation predict that goal-pursuit will depend upon the value of the goal, and the expectancy to obtain this goal (Kruglanski, Shah, Fishbach, Friedman, Chun, & Sleet-Keppler, 2002; Silvia, McCord, & Gendolla, 2010). If people believe that performing the distraction task will reduce their pain, and if they believe that they are able to concentrate on a distraction task during pain (high self-efficacy), performing a distraction task during pain may then become an important goal. However, if they believe that distraction is ineffective in reducing pain, or if they believe that they are unable to concentrate on a distraction task during pain (low self-efficacy), distraction task performance will become a less important goal. This might particularly be the case in high pain catastrophizing individuals as their beliefs about the effectiveness of distraction might be lower. In conclusion, distraction beliefs may play an important role in the priorization of the distraction task over the processing of pain.

Based on this extended model, it can be expected that distraction is less effective in high pain catastrophizing individuals and chronic pain patients, because these individuals may experience difficulties engaging in a distraction task for many reasons. First, they may experience the pain as more intense. The intensity of the pain may then hinder the engagement in a distraction task. Second, they may prioritize the processing of pain over distraction task performance, which would decrease the executive function abilities invested in the distraction task. Third, they may believe that distraction is less effective for them, or may believe that they are unable to concentrate on a distraction task during pain, making distraction task engagement a less important goal. Finally, they may experience a decrease in executive functioning during pain because they worry about pain, or experience executive functioning deficits, which would make it more difficult to optimally employ executive functioning abilities for distraction task performance. However, if the distraction task becomes the prioritized goal, it may be expected that distraction is also effective in high pain catastrophizing individuals and chronic pain patients, because this may optimize the employment of executive functions for distraction task performance, and may overrule the automatic capture of attention by pain.

In conclusion, the role of goal-pursuit may be a key factor in the effectiveness of distraction. Distraction may only be effective when people are able to perform the distraction task (cognition), and also prioritize distraction task performance over the processing of pain (motivation). When the distraction task is the prioritized goal, distraction might even be effective in situations in which the pain is experienced as threatening, intense and novel, and may even be effective in high pain catastrophizing individuals and chronic pain patients, as important goals automatically attract attention and may therefore overrule the attentional capture by pain. Distraction tasks may become more easily prioritized over the processing of pain when they are motivationally relevant, or when beliefs about the effectiveness of distraction are increased, as this may increase the value of this goal and the expectancey to obtain this goal. Future research should further investigate the role of goal-pursuit in the effectiveness of distraction.

IMPLICATIONS FOR CLINICAL PRACTICE

Distraction is often used in daily life, and is part of many pain treatment programs (Morley, Shapiro, & Biggs, 2004; Powers, 1999). However, as previous research has shown, distraction is not always effective for everyone in every situation (Arts et al., 1994; Carlson, Broome, & Vessey, 2000; Cassidy et al., 2002; Goubert et al., 2004; Jaaniste et al., 2007a; Manne, Redd, Jacobsen, Gorfinkle, & Schorr, 1990). The current series of studies confirm this finding, and have shown that influencing factors play a role in the effectiveness of distraction, with the strongest support for the influencing role of pain catastrophizing. Until now, however, practitioners have often used distraction techniques from a one size fits all perspective (e.g., video watching, blowing bubbles, cartoon watching). It is very important for practitioners to acknowledge that distraction is not always effective, allowing a shift to a more individually tailored approach. Practitioners can for instance resist using distraction techniques as a first choice in highly threatening and intense pain situations, or they can decrease the pain intensity or the threat value first before using distraction in these situations. For example, by using medication, by familiarizing the patient with the medical procedure, by decreasing the level of pain catastrophizing, etc. They can also encourage patients to use distraction tasks that are related to important personal goals. Practitioners can also ask patients about their distraction beliefs, and whenever necessary increase these beliefs in order to optimize the effectiveness of distraction. Finally, instead of using distraction as a standard treatment option, practitioners can offer patients a variety of pain coping strategies, allowing them to chose those strategies that they believe are most helpful to them. That way, patients controleability over the pain situation may also increase, which as such may also impact the pain experience.

IMPLICATIONS FOR EXPERIMENTAL RESEARCH

Based on the current series of studies several recommendations can be made for the methodological improvement of future distraction research. Some of these recommendations were already indicated in previous research (see Eccleston, 1995b, for a review), but will continue to be important in future research, and are therefore recapitulated. Others were specifically derived from the current research. An overview is presented in Table 1.

The cold pressor task (CPT) is often used in experimental distraction research, but its use is more complicated than it first appears. The water temperature is an insufficient indicator of pain intensity. The pain experience also depends upon the immersion duration, instructions, the use of a circulating water pump, the immersion of the wrist, the temperature of the water used for the hand standardization, etc. It is therefore recommended to carefully think about the use of the CPT, and its influencing factors when using this pain inducing method in distraction research. It is also recommended to pilot the pain quantity and quality provoked by the CPT as a function of the hypothesis under test. In order to increase the possibility of finding a standard distraction effect, it can be recommended to use a stimulus of moderate pain intensity.

Because of the complex nature of pain, it can be recommended to assess both pain intensity and pain affect, preferably by using multiple items. Pain ratings should be obtained after, instead of during the painful stimulation to avoid interference with the distraction procedure. Confounding influences, such as experimenter bias or memory bias, should be taken into account.

Many distraction studies do not include a control group. Nevertheless, it is impossible to draw conclusions regarding the effectiveness of distraction without using a proper control group. The type of control group used will depend upon the hypothesis under test. For instance, clinical researchers may be interested in investigating whether a specific distraction method is more effective than the coping strategies patients spontaneously use when they are confronted with pain. In this case, the experimental group performs the distraction method under test, and the control group is asked to do whathever they normally do to cope with pain, or does not receive any instructions at all. Fundamental researchers, however, are generally interested in the question whether distraction is effective. In this case, it is important to use a control group that does not use any strategy to control pain, as this may lead to an underestimation of the distraction effect. The current research, however, has shown that control participants generally use spontaneous distraction strategies (e.g., thinking of other things, counting). The use of such strategies can to some point be decreased by instructing the control group. Future research should find ways to further decrease spontaneous coping in fundamental distraction research.

People have detailed views of the effectiveness of distraction. Future research should certainly take these beliefs into account. The easiest way to do so is probably by concealing the purpose of the experiment, for instance by using a cover up story. In all other cases, beliefs should be checked and controlled for.

This research suggests that the engagement with a distraction task might be one of the most important factors in the effectiveness of distraction. Future research should therefore use a distraction task that is based on a theoretical framework. A promising direction for future research is the use of distraction tasks that are related to important personal goals. It is also very important to check the engagement with the distraction task.

Table 1

Methodological guidelines for future distraction research

Pain induction method (general)	• Pilot test pain quality and quantity of the painful stimulus in light of the hypothesis under test • Stimulus of moderate pain intensity might be ideal to study distraction effects • Provide detailed report of the methodology used
Pain induction method (CPT)	• Carefully chose immersion interval and water temperature in light of hypothesis under test • Consider influencing factors (e.g., immersion instructions, circulating water pump) • Use proper exclusion criteria (see guidelines von Baeyer et al., 2005) • Provide detailed report of the methodology used
Distraction task	• Use attention-demanding task • Use underlying theoretical framework • Check and report engagement with the distraction task • Distraction tasks that are related to an important goal might be more effective
Pain measurement	• Assess pain intensity and affect • Use multiple items • Avoid interference with distraction process • Avoid confounding influences (e.g., memory bias, experimenter bias)
Control group	• Always include control group • Type of control group depends upon the hypothesis under test • Decrease spontaneous coping whenever necessary, for instance by using instructions
Other	• Include measurement of pain catastrophizing • Conceal true purpose of experiment or check and control for participants' beliefs • Provide detailed report of instructions used

LIMITATIONS

Results of this dissertation should be in interpreted in light of some limitations. For instance, participants were generally healthy students and schoolchildren. The painful stimulation was created and delivered in the laboratory. Further research is needed to demonstrate whether the current results can be generalized to clinical samples experiencing clinically relevant pain.

Pain was induced with the cold pressor task (CPT). This is a well validated pain induction method that is frequently used in distraction research (e.g., Cioffi & Holloway, 1993; de Wied & Verbaten, 2001; Johnson & Petrie, 1997; McCaul & Haugtvedt, 1982; Van Damme et al., 2008). The CPT, however, has the disadvantage that the pain experience may fluctuate during immersion, with the pain increasing rapidly in the beginning of the immersion and the pain leveling off after 2 to 4 minutes (Eccleston, 1995b; Handwerker, & Kobal, 1993; von Baeyer et al., 2005; Walsh, Schoenfeld, Ramamurthy, & Hoffman, 1989). Therefore we used a fixed immersion paradigm instead of a pain tolerance paradigm to ensure that all participants would experience the same physical stimulation.

The current series of studies employed a between-subjects design. This design has several advantages. Participants are exposed to one instead of two conditions. That way the purpose of the experiment appears less clear, minimizing placebo effects (Eccleston, 1995b). Performing the CPT only once is also less distressing. However, this design needs large research groups to result effects. It is possible that low statistical power might have resulted in the detection of moderate rather than small effect sizes.

Self-report measures were used to assess the pain experience. Pain was assessed after the cold pressor task (CPT) to avoid interference with the distraction process (Eccleston, 1995b). Pain ratings were obtained immediately after the CPT to avoid memory bias (Koyama, Koyama, Kroncke, & Coghill, 2004), and both pain intensity and pain affect were assessed by using multiple items (Fernandez & Turk, 1992), that were based on a theoretical framework (Kahneman, Fredrickson, Schreiber, & Redelmeier, 1993). However, self-report measures can be subject to bias (Hadjistavropoulos & Craig, 2002). Future research, may therefore consider also including alternative pain measurements (e.g., facial pain expression, heart rate, cortisol, EEG). However, it is important to keep in mind that different measurements assess different aspects of the pain, which does not always lead to consistent results across measurements. Also, some pain measurements can be influenced by other characteristics than the pain. For instance, heart rate can be influenced by the pain, but also by the distraction task performance.

In order to increase the possibility of finding a standard distraction effect before testing the hypothesis of influencing factors, the motivation to perform the RIR-task was increased. However, increasing the motivation might also have influenced executive functioning during the cold pressor task (Pessoa, 2009; Sarter et al., 2006; Szatkowska et al., 2008), which might have decreased the possibility of finding differential effects of executive functioning on the pain experience.

Further, it is possible that larger effects of executive functioning may occur in more intense pain situations, or when a more difficult distraction task is used, as inter-individual differences in executive functioning may then become more apparent. In the current series of studies, however, a painful stimulation of moderate intensity was used because distraction is argued to fail in high intense pain situations (Eccleston & Crombez, 1999).

Finally, it would also have been interesting to investigate the relationship between the RIR-task and executive functioning without concurrent pain. Investigating whether participants with better executive functioning abilities would also perform the RIR-task better without concurrent pain, would allow more insight in the relationship between executive functioning and the performance of the RIR-task during pain. For instance, it is possible that participants with better inhibition abilities performed the RIR-task better during pain because they were able to inhibit the pain and focus on the distraction task. However, it is also possible that they performed the RIR-task better, because good RIR-task performance requires inhibition. However, we were unable to investigate the relationship between executive functioning and RIR-task performance without concurrent pain within the current research design (**study 8** and **9**). From a methodological point of view it was better if participants in the distraction group did not perform the RIR-task more than once, as this could negatively influence the interest in the task (see **study 3** and **4**), and we wanted to make the task as interesting as possible to increase the possibility of finding a standard distraction effect. Performing the RIR-task after it was used as a distraction task is also problematic, because taks performance can then be influenced by the preceding painful experience. Including a third group which performed the RIR-task without concurrent pain, could also have been an alternative. However, it would have been better to study the relationship between executive functioning and RIR-task performance using a within-subjects design. Also, the research samples were already substantial and time constraints made it impossible to add another group. Future research might further investigate the relationship between the RIR-task and executive functioning.

FUTURE RESEARCH DIRECTIONS

The current research has shown that cognitive engagement in a distraction task does not always lead to a reduction in pain. It is possible that distraction will only be effective when people are able to engage in the distraction task (cognition), but also prioritize this task over attending to the pain (motivation). Cognitive models of attention may therefore be insufficient in explaining distraction effectiveness, and cognitive-motivational models might be more suitable for explaining distraction effects, and may be more useful for future distraction research. According to these models, goal-pursuit might be a key factor in the effectiveness of distraction, as it (1) may play an important role in overruling the attentional capturre of bottom-up characteristics of the pain, (2) may determine the amount of executive functions that are employed for distraction task performance, and (3) may particularly be important in high pain catastrophizing individuals. Distraction studies, which use cognitive models as the underlying theoretical framework, without taken into account this goal-perspective, may not find distraction effects or may lack information to explain study results, and as a result may contribute to the large pile of inconsistent results in distraction research. To illustrate this, goal-pursuit might explain why some studies have found beneficial effects of distraction, whereas others did not find effects of distraction. It is possible that participants in the studies which did not find effects of distraction did not prioritize the distraction task over the processing of pain, for example, because the distraction task was not very interesting, or because participants did not believe in the effectiveness of distraction or in their ability to engage in a distraction task, or because participants found it more important to pay attention to the pain (e.g., high pain catastrophizing participants). Goal-pursuit might also explain why some studies have found counterproductive effects of distraction, whereas others did not. If participants are instructed to engage in a distraction task, and this is not their prioritized goal, complying with the instruction to engage in a distraction task may create frustration, which may increase the pain experience. Finally, the motivation to perform the distraction task may also explain why some studies found distraction to be more effective when distraction tasks are used that demand more cognitive resources, whereas others did not find these results (see Buhle & Wager, 2010 for a review). When distraction taks are too difficult, this may decrease the motivation to engage in these tasks. In conclusion, it is important for future research to check the engagement with the distraction task, and also to check the motivation to perform the distraction task and balance it against the motivation to attend to the pain. That way distraction effects may be more easily detected and lacking distraction effects may be more easily explained.

Motivational distraction tasks may be more effective in reducing pain, because they are more likely to get prioritized over the processing of pain. A challenge for future experimental distraction research will therefore be to develop tasks that relate to personal goals. One way to create motivation in an experimental context is the use of money, a method that was also applied in the current research. This method is often used in research in adults (Bonner & Sprinkle, 2002), but also in children and adolescents (Kohls, Peltzer, Herpertz-Dahlmann, & Konrad, 2009). Other ways to increase motivation are for instance providing feedback when performing the distraction task (Bonner & Sprinkle, 2002). For example, using videogames in which participants' scores are displayed. It is also possible to perform research in samples with a specific need. For instance, using distraction tasks with a religious content in highly religious participants, or using distraction tasks that are food-related in hungry people. In clinical practice, distraction tasks can be used that are related to the patients' hobbies.

This dissertation examined the relationship between distraction effectiveness and executive functioning. Results showed a relationship between executive functioning and distraction task engagement. However, no relationship was found between executive functioning and the effectiveness of distraction in terms of pain reduction. It is possible that executive functioning does not play a role in the effectiveness of distraction. However, it is also possible that a relationship will occur when investigating executive functioning abilities in relationship with other influencing factors, such as motivation. Future research might therefore investigate the relationship between distraction effectiveness, executive functioning abilities and motivation. In order to improve the measurement of executive functioning abilities, several recommendations can be made. For instance, in the current research, executive functioning was assessed using general measurements of executive functioning. However, the relationship between executive functioning and distraction effectiveness may be stronger when executive functioning is examined during the painful stimulation. Future research might investigate the relationship between pain-related executive functioning and distraction effectiveness, for instance by developing research paradigms that assess executive functioning during pain. A suggestion might be to use the switching task and the anti-saccade task here used, with alternating painful and non-painful trials. The task performance on painful trials can be used as measurements of pain-related inhibition and task switching abilities, whereas the performance on non-painful trials can be used as measurements of general inhibition and task switching abilities. Both can be used as predictors for distraction effectiveness during an independent subsequent paintest. The assessment of executive functioning might also be improved by using a multi-method approach. That way a structural equation approach can be used to improve the reliability of its measurement. Finally, research populations with even more diversity in executive functioning might be used to facilitate the detection of effects of executive functioning (e.g., general population).

It is well established now that distraction is indeed less effective in high catastrophizing individuals. Several underlying mechanisms might be responsible for these findings. It can be expected that performing a distraction task during pain is not the focal goal for high pain catastrophizers. Using a distraction task that is related to an important goal may then be necessary to overcome the attentional capture of pain. As a result, distraction might also be effective in high pain catastrophizing individuals. In low pain catastrophizing individuals, pain processing might be a less important goal, making it easier for any distraction task to become prioritized over the processing of pain. It is however unclear whether high pain catastrophizers' goals indeed differ from low pain catastrophizers' goals. Future research might investigate goals in high and low pain catastrophizing individuals in general, and in particular during pain. For instance, by developing questionnaires about pain-related and alternative goals that can then be related to a measurement of pain catastrophizing. Further, distraction might be less effective in high pain catastrophizing individuals because their executive functioning capacity might be lower during pain or in general, which could hinder the optimal employment of executive functioning abilities for distraction task performance. Future research may investigate whether high pain catastrophizers' executive functioning is indeed lower during pain, compared to low pain catastrophizers, and whether a decrease in executive functioning is the result of a general deficit in executive functioning, or only occurs in the context of pain. For instance, by investigating the relationship between pain catastrophizing and the performance on general executive functioning tasks and pain-related executive functioning tasks (see supra). Finally, this dissertation has shown that high pain catastrophizers believe distraction to be more effective for others than for themselves. It is possible that distraction is less effective in high pain catastrophizers because they have different beliefs about the effectiveness of distraction than low pain catastrophizers. These beliefs may influence the engagement with the distraction task, or may in itself produce pain relief. Future research might further explore distraction beliefs in high pain catastrophizers, for instance by using vignettes, or by developing questionaires.

Finally, this research was performed in healthy participants. Future research needs to test these research questions in a population of participants experiencing clinically relevant pain.

CONCLUSION

This research has investigated the effectiveness of distraction in a population of schoolchildren and university students, and examined its relationship with beliefs, pain catastrophizing and executive functioning. Results suggest that cognitive models of attention are insufficient in explaining distraction effectiveness. Cognitive-motivational models of attention may be more useful in explaining effects of distraction. According to these models, the effectiveness of distraction is likely to depend upon the interaction between bottom-up factors (e.g. characteristics of the pain) and top-down factors (e.g., goal-pursuit). Results of the current dissertation were used to extend these models by incorporating beliefs, executive functioning and pain catastrophizing. This extended model suggest that goal-pursuit might be a key factor in the effectiveness of distraction, as goal-pursuit (1) may play an important role in overruling the attentional capture of bottom-up characteristics of the pain, (2) may determine the amount of executive functions that are employed for distraction task performance, and (3) may particularly be important in high pain catastrophizing individuals. Future research is, however, necessary to further explore the role of goal-pursuit in distraction.

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NEDERLANDSTALIGE SAMENVATTING

INLEIDING

Pijn is een onaangename ervaring met sensorische en emotionele karakteristieken (IASP, 1994), die vaak voorkomt en een grote invloed kan hebben op het dagelijkse leven (Breivik, Collett, Ventafridda, Cohen, & Gallacher, 2006; Gauntlett-Gilbert, & Eccleston, 2007; Perquin et al., 2000). Onderzoek naar pijnreducerende technieken is daarom van groot belang. Aandachtsafleiding, of distractie, is een techniek die mensen vaak intuïtief gebruiken om met de pijn om te gaan (Leventhal, 1992). Deze techniek wordt eveneens vaak gebruikt bij de klinische behandeling van pijn (Morley, Shapiro, & Biggs, 2004; Powers, 1999). Distractie is een proces waarbij men de aandacht wegricht van een pijnlijke stimulus en ze vervolgens engageert in iets anders, met een pijnreductie tot gevolg (Eccleston, 1995b; Fernandez, 1986; Piira, Hayes, & Goodenough, 2002). De werkzaamheid van distractie lijkt intuïtief aannemelijk, doch onderzoek naar de effectiviteit van deze techniek vertoont echter tegenstrijdige resultaten. Studies bij volwassenen rapporteren vaak positieve effecten van distractie op de pijnervaring (Campbell et al., 2010; James & Hardardottir, 2002; Johnson, Breakwell, Douglas, & Humphries, 1998; Johnson & Petrie, 1997; Miron, Duncan, & Bushnell, 1989; Terkelsen, Andersen, Mølgaard, Hansen, & Jensen, 2004; Veldhuijzen, Kenemans, de Bruin, Olivier, & Volkerts, 2006). Andere studies beschrijven echter geen effecten (Hodes, Howland, Lightfoot, & Cleeland, 1990; McCaul, Monson, & Maki, 1992), of zelfs negatieve effecten van distractie (Buckelew et al., 1992; Cioffi & Holloway, 1993; Goubert, Crombez, Eccleston, & Devulder, 2004). In tegenstelling tot het onderzoek bij volwassenen, rapporteert het onderzoek bij kinderen en adolescenten overwegend positieve effecten van distractie op de pijnervaring (Chambers, Taddio, Uman, & McMurtry, 2009; DeMore & Cohen, 2005; Kleiber & Harper 1999; Uman, Chambers, McGrath, & Kisley, 2008). De resultaten zijn echter inconsistent wat betreft de verschillende uitkomstmaten (bv. pijnintensiteit, tolerantie, pijnaffect, pijngedrag), de personen die de aandacht afleiden (bv. kind, ouders, verpleegsters) en de setting waarbinnen de distractie bestudeerd wordt (bv. laboratorium, klinische praktijk). Tegenstrijdige onderzoeksresultaten wijzen erop dat distractie niet voor iedereen in elke situatie effectief is (Eccleston & Crombez, 1999; Piira et al., 2002).

Heterogene onderzoeksresultaten kunnen het gevolg zijn van methodologische verschillen tussen onderzoeken (bv. gebruik van verschillende pijninductiemethoden, pijnmetingen, distractietaken, instructies, …), alsook van methodologische zwaktes in onderzoeksdesigns (zie Eccleston, 1995b voor een review; Piira et al., 2002). Zo worden de pijnmetingen vaak uitgevoerd tijdens de distractieprocedure, wordt het engagement in de distractietaak zelden gemeten, ontbreekt er vaak een geschikte controlegroep etc. Deze methodologische problemen kunnen de interne validiteit van studies bedreigen en de veralgemeenbaarheid van de resultaten bemoeilijken. Heterogene onderzoeks-resultaten kunnen echter ook wijzen op de rol van modererende variabelen (Eccleston & Crombez, 1999; Kleiber & Harper, 1999; Piira et al., 2002). Onderzoek naar de rol van dergelijke variabelen in de werking van distractie is echter schaars, zeker bij kinderen en adolescenten.

Er zijn verschillende variabelen die de effectiviteit van distractie mogelijk kunnen beïnvloeden. Zo zouden de *opvattingen* over de werking van distractie de effectiviteit van deze techniek kunnen beïnvloeden. Het kan verwacht worden dat distractie effectiever is voor mensen die geloven in de effectiviteit van distractie. Niet alleen zouden de opvattingen het engagement in de distractietaak kunnen beïnvloeden, maar ze zouden ook een rechtstreekse invloed kunnen hebben op de pijnervaring (cfr. placebo) (Leventhal, 1992). Onderzoek over de opvattingen van distractie is echter schaars, en bij kinderen en adolescenten zelfs onbestaand (Ahles & Blanchard, 1983; McCaul & Haugtvedt, 1982). Daarnaast zou *catastroferen* (d.i., de neiging om overdreven negatief te reageren op pijnervaringen) een belangrijke modererende variabele kunnen zijn in de effectiviteit van distractie. Onderzoek toonde immers aan dat hoogcatastrofeerders hypervigilant zijn voor pijn, en hun aandacht minder makkelijk kunnen loskoppelen van de pijn, wat vermoedelijk het engagement in de distractietaak zou bemoeilijken (Crombez, Eccleston, Baeyens, & Eelen, 1998a; 1998b; Quartana, Campbell & Edwards, 2009; Van Damme, Crombez, & Eccleston, 2004). Deze hypothese vond reeds enige bevestiging in studies bij volwassenen (Campbell et al., 2010; Goubert et al., 2004; Heyneman, Fremouw, Gano, Kirkland, & Heiden, 1990; Spanos, Radtke-Bodorik, Ferguson, & Jones, 1979), maar werd nooit eerder onderzocht in een populatie van kinderen en adolescenten. Tenslotte zouden *executieve vaardigheden* de effectiviteit van distractie kunnen beïnvloeden. Distractie zou slechts effectief kunnen zijn (1) als men de automatische tendens om aandacht te besteden aan de pijn, alsook de interruptie van pijn, kan inhiberen (Friedman & Miyake, 2004; Nigg, 2000), (2) als men de aandacht kan terugswitchen naar de distractietaak telkens als de pijn aandacht opeist (Eccleston, 1995a), en (3) als de informatie die belangrijk is om een distractietaak uit te voeren prioriteit krijgt in het werkgeheugen (Dalton, Lavie, & Spence, 2009; Dalton, Santangelo, & Spence, 2009; Lavie & de Fockert, 2005). Meer specifiek kunnen we verwachten dat distractie effectiever zal zijn voor personen met betere inhibitie - en taakswitchingvaardigheden en een grotere werkgeheugencapaciteit. Deze hypothese werd echter nog nooit onderzocht. Omdat executieve vaardigheden zich ontwikkelen doorheen de kindertijd en verder geoptimaliseerd worden tijdens de adolescentie, is het interessant om deze hypothese te toetsen in een steekproef van kinderen en adolescenten. Dit zou voldoende heterogeniteit in executieve vaardigheden moeten garanderen om het detecteren van effecten te vergemakkelijken (Cepeda, Kramer, & Gonzales de Sather, 2001; Huizinga, Dolan, & van der Molen, 2006).

DOELSTELLINGEN

Het doctoraat had als doel om meer inzicht te verwerven in de onderliggende processen van distractie om aldus het gebruik van deze techniek te optimaliseren. Drie belangrijke onderzoeksdoelstellingen stonden hierbij centraal. Allereerst bestudeerden we de opvattingen van kinderen en adolescenten over de werkzaamheid van distractie om een algemeen beeld te vormen over hoe de onderzoekspopulatie van dit doctoraat denkt over de werkzaamheid van deze techniek. Daarnaast ontwikkelden we een onderzoeksprotocol om de werking van distractie te bestuderen in een experimentele context. Er werd hierbij rekening gehouden met de methodologische tekortkomingen in eerder onderzoek (Eccleston, 1995b). Ten slotte gebruikten we dit onderzoeksprotocol om de effectiviteit van distractie en de modererende rol van catastroferen en executieve functies (e.g., inhibitievaardigheden, taakswitchingvaardigheden en werkgeheugencapacitiet) te bestuderen. Het doctoraat bestaat uit vier delen, die zes hoofdstukken bevatten met in totaal negen studies.

RESULTATEN

Opvattingen over distractie

In **deel 1**, dat bestaat uit **hoofdstuk 1**, bestudeerden we de opvattingen over de werking van distractie in een proefgroep van studenten (*N*=263) (**studie 1**) en schoolkinderen (*N*=617) (**studie 2**). In beide studies gebruikten we een vignettenparadigma, waarbij de proefpersonen zich moesten inleven in verschillende hypothetische pijnsituaties en de mate moesten aangeven waarin zij geloofden dat aandachtsafleiding in de gegeven situatie zou werken om de pijn te verminderen. In de tweede studie bestudeerden we eveneens het geloof in de werking van sensory-focusing, een copingstrategie waarbij men de aandacht richt op de pijn, zonder die op een affectieve manier te verwerken. Aangezien opvattingen vaak beïnvloed worden door individuele en situationele factoren, onderzochten we tevens of de opvattingen over de werking van distractie beïnvloed worden door karakteristieken van de pijn (intensiteit, nieuwheid, dreigwaarde), en de mate van catastroferen. De resultaten toonden aan dat proefpersonen geloofden in de werking van distractie (**studie 1** en **2**). Proefpersonen geloofden tevens dat distractie beter zou werken om de pijn te verminderen dan sensory-focusing (**studie 2**). De opvattingen over de werkzaamheid van distractie waren echter minder sterk dan verwacht en werden beïnvloed door de karakteristieken van de pijn. Proefpersonen geloofden dat distractie minder effectief zou zijn in situaties waarin de pijn bedreigend is (**studie 1** en **2**). Ze geloofden tevens dat distractie minder goed zou werken in intense pijn situaties (**studie 1**). De nieuwheid van de pijn had geen invloed op de opvattingen over de werkzaamheid van distractie (**studie 1** en **2**). De resultaten werden niet beïnvloed door de mate van catastroferen (**studie 1** en **2**).

De resultaten van **deel 1** toonden aan dat kinderen en adolescenten een gedetailleerd beeld hebben over de werkzaamheid van distractie. Aangezien opvattingen over de werkzaamheid van distractie een invloed kunnen hebben op de effectiviteit van deze techniek (Leventhal, 1992), lijkt het aangewezen om in verder experimenteel onderzoek rekening te houden met deze opvattingen. Dit kan enerzijds door het doel van het experiment te verhullen, anderzijds door de opvattingen over de werkzaamheid van distractie in kaart te brengen en hiervoor te controleren.

Ontwikkeling van een distractieparadigma

In **deel 2**, dat bestaat uit **hoofdstuk 2**, voerden we twee studies uit, waarin de effectiviteit van distractie in een experimentele context bestudeerd werd (**studies 3** en **4**). Het doel van deze studies was om een distractieparadigma (koudwatertest) te ontwikkelen, dat gebruikt kon worden voor verder experimenteel onderzoek. Hierbij hielden we rekening met de methodologische tekorten in eerder distractieonderzoek. We verwachtten dat proefpersonen in de distractiegroep minder aandacht zouden besteden aan de pijn, en bijgevolg minder pijn zouden ervaren dan proefpersonen in de controlegroep.

In **studie 3** dompelden 39 studenten hun hand onder in koud water van 7 °C gedurende 2 minuten. De helft van de proefpersonen voerde tegelijk een aandachtsopeisende toondetectietaak uit (distractiegroep), de andere helft voerde geen taak uit (controlegroep). In tegenstelling tot wat verwacht werd, besteedden proefpersonen in de distractiegroep niet minder aandacht aan de pijn dan proefpersonen in de controlegroep. De aandachtsmanipulatie was dus ineffectief. De mate van ervaren pijn tijdens de koudwatertst verschilde dan ook niet in beide groepen.

In **studie 4** brachten we methodologische verbeteringen aan. Ditmaal dompelden proefpersonen (N=93) hun hand onder in water van 7 °C of 10 °C. De aandachtsmanipulatie bleek opnieuw ineffectief. De mate van ervaren pijn tijdens de koudwatertst verschilde ook nu niet in beide groepen. De temperatuur van het water beïnvloedde de resultaten niet.

De resultaten van **deel 2** toonden aan dat het bestuderen van distractie niet zo eenvoudig is als het lijkt. We formuleerden suggesties om het distractieprotocol verder op punt te stellen voor toekomstig onderzoek.

Distractie en catastroferen

In **deel 3**, dat **hoofdstuk 3** en **hoofdstuk 4** omvat, stelden we het distractieparadigma verder op punt. Vervolgens gebruikten we dit paradigma om de effectiviteit van distractie en de modererende invloed van catastroferen te bestuderen. We verwachtten dat distractie minder effectief zou zijn voor proefpersonen die hoog scoorden op catastroferen.

In **hoofdstuk 3** bestudeerden we de effectiviteit van distractie en de modererende rol van catastroferen in een proefgroep van studenten (**studie 5**). Participanten (*N*=73) dompelden hun hand onder in water van 12 °C gedurende 1 minuut. Proefpersonen werden op toevallige wijze toegewezen aan drie verschillende groepen. Proefpersonen in de eerste groep voerden tijdens de onderdompeling in het koude water een aandachtsopeisende toondetectietaak uit (distractiegroep 1). Proefpersonen in de tweede groep konden geld verdienen door dezelfde toondetectietaak uit te voeren (distractiegroep 2). We voegden deze groep toe om na te gaan of we de effectiviteit van distractie zou kunnen optimaliseren door de motivatie om een distractietaak uit te voeren te verhogen. Participanten in de derde groep voerden geen distractietaak uit (controlegroep). De resultaten toonden aan dat distractie effectief was in beide distractiegroepen. Proefpersonen in beide groepen besteedden minder aandacht aan pijn en rapporteerden minder pijn dan proefpersonen in de controlegroep. De pijnbeleving verschilde niet in de beide distractiegroepen. De resultaten waren echter afhankelijk van de mate van catastroferen. Distractie was effectief voor laagcatastrofeerders, ongeacht de distractiegroep. Voor hoogcatastrofeerders was distractie zoals verwacht ineffectief, maar bleek distractie ook effectief te zijn als de motivatie om zich te engageren in de distractietaak verhoogd werd. De effectiviteit van distractie kan dus toenemen als de motivatie om een distractietaak uit te voeren verhoogd wordt, maar dit lijkt vooral het geval te zijn voor hoogcatastrofeerders.

In **hoofdstuk 4** bestudeerden we de relatie tussen distractie en catastroferen in een proefgroep van schoolkinderen. Proefpersonen (*N*=828) namen eerst deel aan een vragenlijststudie (PCQ; Bandell-Hoekstra et al., 2002; Reid, Gilbert, & McGrath, 1998) over het gebruik van aandachtsafleiding in het dagelijkse leven (**studie 6**). Resultaten toonden aan dat hoogcatastrofeerders minder distractie gebruiken in hun dagelijkse leven dan laagcatastrofeerders. Vervolgens nam een random geselecteerde subgroep deel aan een experimentele studie over de werking van distractie (*N*=81) (**studie 7**). Proefpersonen werden op toevallige wijze toegewezen aan een distractiegroep, die een aandachtsopeisende toondetectietaak uitvoerde tijdens de onderdompeling van hun hand gedurende 1 minuut in water van 12 °C, of een controlegroep die geen taak uitvoerde. De resultaten toonden aan dat proefpersonen in de distractiegroep zich concentreerden op de distractietaak en minder aandacht aan de pijn besteedden dan proefpersonen in de controlegroep. Distractie was echter ineffectief om de pijnervaring te verminderen. Hoogcatastrofeerders rapporteerden zelfs meer pijn in de distractiegroep.

De resultaten van **deel 3** tonen aan dat catastroferen een belangrijke moderator is in de werkzaamheid van distractie. Deze studies bevestigden de ineffectiviteit van distractie bij hoogcatastrofeerders, die reeds eerder aangetoond werd in onderzoek bij volwassenen voor een populatie van kinderen en adolescenten. Daarnaast toonden we aan dat distractie wel degelijk effectief kan zijn voor hoogcatastrofeerders als de motivatie om zich te engageren in de distractietaak verhoogd wordt. Motivatie speelt waarschijnlijk een grotere rol bij hoogcatastrofeerders, omdat zij pijnverwerking mogelijk als een belangrijker doel beschouwen dan laagcatastrofeerders. Het is aannemelijk dat hoogcatastrofeerders een extra stimulans nodig hebben om een alternatief doel belangrijker te vinden dan de verwerking van pijn. Of men het uitvoeren van de distractietaak inderdaad belangrijker acht dan het verwerken van pijn hangt echter af van persoon tot persoon en van situatie tot situatie. Distractie is dus niet voor iedereen in elke situatie effectief en catastroferen lijkt hierin een belangrijke rol te spelen.

Distractie en executieve vaardigheden

In **deel 4**, dat **hoofdstuk 5** en **hoofdstuk 6** omvat, gebruikten we het distractieparadigma om de effectiviteit van distractie en de modererende invloed van executieve vaardigheden te onderzoeken. We verwachtten dat distractie effectiever is voor personen met betere executieve vaardigheden.

In **hoofdstuk 5**, onderzochten we de effectiviteit van distractie, en de modererende invloed van executieve vaardigheden in een proefgroep van studenten (**studie 8**). Deelnemers (*N*=91) voerden eerst verschillende taken uit, die het algemene executieve functioneren meten. Inhibitievaardigheden werden gemeten met de antisaccadetaak (Miyake, Friedman, Emerson, Witzki, & Howenter, 2000), taakswitchingvaardigheden werden gemeten met het taakswitchingparadigma (Meiran, Chorev, & Sapir, 2000), en de werkgeheugencapaciteit werd gemeten met de digitspantaak van de WAIS-III (Wechsler, 2005). Vervolgens dompelden de proefpersonen hun hand onder in water van 12 °C gedurende 1 minuut. De helft van de proefpersonen voerde tegelijk een aandachtsopeisende toondetectietaak uit (distractiegroep), de andere helft voerde geen taak uit (controlegroep). De resultaten toonden aan dat proefpersonen in de distractiegroep minder pijn rapporteerden tijdens de koudwatertest, dan proefpersonen in de controlegroep. De mate van executief functioneren beïnvloedde de pijnervaring echter niet. In tegenstelling tot wat verwacht werd, werkt distractie dus niet beter voor proefpersonen met betere executieve vaardigheden. De mate van executief functioneren beïnvloedde wel de prestatie op de aandachtsafleidende taak. Proefpersonen met betere inhibitievaardigheden presteerden beter op de distractietaak. We zouden hieruit kunnen afleiden dat inhibitievaardigheden betrokken zijn bij het uitvoeren van taken tijdens pijn.

In **hoofdstuk 6** bestudeerden we de effectiviteit van distractie en de modererende invloed van executieve vaardigheden in een proefgroep van schoolkinderen (**studie 9**). Proefpersonen (*N*=162) voerden eerst verschillende taken uit, die het algemene executieve functioneren meten. Inhibitievaardigheden werden gemeten met de antisaccadetaak (Miyake et al., 2000) en de kleurwoordtest (Stroop, 1935), taakswitchingvaardigheden werden gemeten met het taakswitchingparadigma (Meiran et al., 2000), en de werkgeheugencapaciteit werd gemeten met de digitspantaak van de WISC-III^{NL} (Kort et al., 2005). Vervolgens dompelden de proefpersonen hun hand onder in water van 12 °C gedurende 1 minuut. De helft van de proefpersonen voerde tegelijk een aandachtsopeisende toondetectietaak uit (distractiegroep), de andere helft voerde geen taak uit (controlegroep). De resultaten toonden aan dat de proefpersonen in de distractiegroep zich concentreerden op de distractietaak en minder aandacht besteedden aan de pijn dan de proefpersonen in de controlegroep. De mate van executief functioneren beïnvloedde het engagement in de distractietaak. Proefpersonen met betere inhibitievaardigheden en een grotere werkgeheugencapaciteit presteerden beter op de distractietaak. Proefpersonen met betere taakswitchingvaardigheden besteedden meer aandacht aan de distractietaak. Distractie was echter ineffectief om de pijnervaring te verminderen. De mate van executief functioneren beïnvloedde de effectiviteit van distractie niet, maar was wel gerelateerd aan de algemene beleving van pijn. Meer bepaald vonden proefpersonen met betere inhibitievaardigheden en een grotere werkgeheugencapaciteit de koudwatertest minder onaangenaam en stresserend.

De studies uit **deel 4** konden geen relatie aantonen tussen de mate van executief functioneren en de effectiviteit van distractie. Distractie werkt dus niet beter voor kinderen en adolescenten met betere executieve vaardigheden. De mate van executief functioneren beïnvloedde wel de wijze waarop de distractietaak uitgevoerd werd. We vonden vooral evidentie voor de rol van inhibitievaardigheden. Hoe beter de inhibitievaardigheden, hoe beter de prestatie op een taak tijdens pijn. Het is mogelijk dat de relatie tussen de effectiviteit van distractie (d.i., een reductie in pijn) en het executieve functioneren beïnvloed wordt door andere factoren, zoals motivatie. Toekomstig onderzoek zal hierover echter uitsluitsel moeten bieden.

DISCUSSIE

De resultaten van dit onderzoek toonden aan dat de cognitieve betrokkenheid in een distractietaak niet steeds volstaat om de pijn te verminderen (**studies 3**, **4**, **5**, **7** en **9**). De relatie tussen de mate van cognitief functioneren en de effectiviteit van distractie wordt waarschijnlijk ook beïnvloed door andere factoren (bv. motivatie) (**studies 8** en **9**). Dit toont aan dat cognitieve aandachtsmodellen, die stellen dat de mate waarin men cognitief geëngageerd is in de distractietaak de effectiviteit van distractie zal beïnvloeden, onvoldoende zijn om de werkzaamheid van distractie te verklaren. De resultaten pleiten meer voor de bruikbaarheid van cognitief-motivationele aandachtsmodellen om de effectiviteit van distractie te verklaren (Eccleston & Crombez, 1999; Legrain et al., 2009; Van Damme, Legrain, Vogt, & Crombez, 2010). Volgens deze modellen zal de mate waarin de pijn aandacht opeist, en dus ook de mate waarin distractie effectief is, afhangen van de dynamische interactie tussen bottomup karakteristieken van de pijn (bv. intensiteit, nieuwheid en dreigwaarde), die het engagement in een distractietaak kunnen bemoeilijken, en topdown cognitieve factoren (bv. executieve vaardigheden) en motivationele factoren (bv. nastreven van doelen en inhiberen van doelirrelevante informatie), die het engagement in een distractietaak eveneens kunnen beïnvloeden. Distractie zal volgens deze modellen effectief zijn als de aandachtasfleidende taak belangrijker geacht wordt dan de verwerking van pijn. In dit geval zal de aandachtsfaleidende taak automatisch de aandacht trekken, zullen executieve functies ingezet worden om de prestatie op de aandachtsafleidende taak te bevorderen en om taakirrelavante informatie (bv. pijn) te inhiberen, en zou de invloed van pijnkarakteristieken op het distractietaakengagment verminderd kunnen worden. Opvattingen over de werkzaamheid van distractie zouden de mate waarin de distractietaak belangrijk geacht wordt, kunnen beïnvloeden. Volgense deze modellen zullen motivationele aandachtsafleidende taken (bv. hobbies) meer kans hebben om belangrijker geacht te worden dan de pijn, en zullen deze taken daarom effectiever zijn om de pijn te verminderen. Het gebruik van dergelijke taken lijkt vooral van belang te zijn bij hoogcatastrofeerders. De validiteit van deze cognitieve-motivationele modellen zal echter verder aangetoond moeten worden in vervolg onderzoek.

KLINISCHE IMPLICATIES

Distractie wordt vaak gebruikt in klinische pijnbehandelingen. Vaak wordt deze techniek gebruikt vanuit een "one size fits all" optiek. Resultaten toonden echter aan dat distractie niet effectief is voor iedereen in elke situatie. Er zou dus beter geopteerd worden voor een meer geïndividualiseerde aanpak. Dit onderzoek toonde aan dat het gebruik van distractie geoptimaliseerd kan worden door deze techniek niet als eerste keuze te gebruiken in situaties van intense pijn of in situaties waarin de pijn als bedreigend ervaren wordt, omdat de pijn dan automatisch de aandacht trekt. Indien men wel distractie wilt gebruiken in deze situaties, lijkt het aangewezen om eerst de intensiteit van de pijn te verminderen (bv. door medicatie te geven) of de dreigwaarde van de pijn te verminderen alvorens distractie te gebruiken (bv. door patiënten vertrouwd te maken met de medische procedure, door informatie te geven over de ingreep of door de mate van catastroferen te verminderen d.m.v. cognitieve gedragstherapie). De effectiviteit van distractie zou tevens geoptimaliseerd kunnen worden door patiënten te overtuigen van de werkzaamheid van deze techniek. Patiënten kunnen ook leren om hun executieve vaardigheden optimaal te gebruiken (bv. door mindfulness training), zodat ze zich beter kunnen concentreren op een distractietaak. Tenslotte kan het aanbevolen worden om distractietaken te gebruiken die belangrijk zijn voor de patiënten (bv. hobbies), aangezien belangrijke doelen automatisch de aandacht trekken. Het gebruik van dergelijke taken zou voornamelijk de effectiviteit van distractie kunnen optimaliseren bij hoogcatastrofeerders.

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